BRICS

RUSSIA | 2020

# STI OVERVIEW

Five-Year Anniversary of Cooperation
in Science, Technology and Innovation
under the Memorandum of Understanding

# Contents:

## MARCOS PONTES

### MINISTER OF SCIENCE, TECHNOLOGY AND INNOVATION
### Federative Republic of Brazil

Science, technology and innovation are one of the best tools we have to bring countries closer to work together; we see here in the BRICS framework that we have similar difficulties, needs and aspirations and that cooperation is still very promising. Considering the common global challenges we face today, it is clear we all depend on science to survive and improve our quality of life.

## VALERY FALKOV

### MINISTER OF SCIENCE AND HIGHER EDUCATION
### Russian Federation

By now, BRICS has established itself as an influential factor in economic and political world processes. The purpose of the association is to develop joint responses to a wide range of international challenges to ensure sustainable development and long-term economic growth.

## HARSH VARDHAN

### MINISTER OF SCIENCE AND TECHNOLOGY
### Republic of India

Cooperation in the fields of science and technology and applied research among BRICS nations would help resolve issues and challenges that the world faces currently.

## WANG ZHIGANG

### MINISTER OF SCIENCE AND TECHNOLOGY
### People`s Republic of China

The Chinese government attaches great importance to the development of STI, giving it top priority in overall national development. The Chinese government values STI, as well as openness and cooperation, because science knows no borders. Science and technology is a great creative undertaking of mankind and developing science and technology calls for a global vision and a grasp of the trend of the times.

## BONGINKOSI EMMANUEL "BLADE" NZIMANDE

### MINISTER OF HIGHER EDUCATION, SCIENCE AND INNOVATION
### Republic of South Africa

The BRICS countries need to strengthen scientific and technical knowledge sharing. Academic and institutional collaboration were identified as powerful tools in promoting intra-BRICS cooperation and expanding the current body of knowledge on the BRICS countries both as individual members, and as a collective.

**SINCE 2008, THE FIVE BRICS COUNTRIES HAVE FULLY ACCOUNTED FOR 56% OF GLOBAL GROWTH [1]. SCIENCE, TECHNOLOGY AND INNOVATION (STI), AS AN ESSENTIAL CORE FOR MODERN ECONOMIC DEVELOPMENT AND SOCIAL PROSPERITY, GAINED A PIVOT ROLE IN COLLABORATION WITH MEMBER-STATES.**

# PREFACE

Today, the BRICS countries account for almost a third of global GDP (in terms of purchasing power parity of national currencies; in 2018, the BRICS surpassed the G7 in terms of this indicator - USD 44 trillion). The population of these five states is 42% of the world's population (about 3 billion people), the territory is 26% of the earth's land. The countries of the "five" have impressive reserves of natural resources.

Over time, BRICS has developed into a multidisciplinary strategic partnership based on three key pillars: politics and security, economics and finance, culture and humanitarian ties. Relations between BRICS partners are built on the basis of equality and mutual respect, as well as the principles of openness, pragmatism, solidarity, and non-orientation against third parties.

[1] Reddy S., 2018. The Growing BRICS Economies: An INET Series. Institute for New Economic Thinking. Retrieved on September 1, from https://www.ineteconomics.org/perspectives/blog/the-growing-brics-economies-an-inet-series

# PRIOR TO THE MEMORANDUM ON STI COOPERATION

In line with the mandate of the eThekwini Declaration and Action Plan of March 2013 adopted at the V BRICS Summit in South Africa, the BRICS STI Ministers and their representatives officially met for the first time on February, 2014, at Cape Town (South Africa). The Meeting was the result of five years of close and efficient collaboration between the parties. Despite the fact that these early years of cooperation fell apart during the search for a quick recovery after the global financial crisis, BRICS countries managed to establish coordination within the multilateral framework and broad-based initiatives to expand areas of collaboration. As an important driving force of transition to a more representative and equitable system of inclusive global growth and stability, BRICS also became a response to political tensions worldwide.

The Meeting of the BRICS STI Ministers and their representatives for STI reaffirmed the principles of openness and continuity determined by five thematic areas and leadership:

| THEMATIC AREAS | LEADERSHIP |
|---|---|
| Prevention and monitoring of natural disasters | Brazil |
| Water resources and pollution treatment | Russia |
| Geospatial technology and its applications | India |
| New and renewable energy | China |
| Astronomy | South Africa |

These topics were reflected in the Strategy for BRICS Economic Partnership together with:

- food security and sustainable agriculture; nanotechnology;
- high-performance computing;
- basic research;
- space research and exploration, aeronautics, and earth observation;
- medicine and biotechnology;
- biomedicine and life sciences (biomedical engineering, bioinformatics, biomaterials);
- information and communication technology;
- clean coal technologies;
- natural gas and non-conventional gases; and
- ocean and polar sciences.


The considerable progress in STI incomes and outcomes of BRICS countries directly affects productivity growth. Closely linked to government policy, this progress cannot be seen as a sporadic individual movement, but as a collaborative growth, based on joint management of resources and capabilities together with collective knowledge.

It consists of the interaction and synergy of three segments, namely scientific organizations, universities, governments and business, simultaneously playing their individual roles. The mutual connectivity of all three sectors was prescribed by the BRICS Memorandum of Understanding on Cooperation in Science, Technology and Innovation between the Governments of the Federative Republic of Brazil, the Russian Federation, the Republic of India, the People's Republic of China and the Republic of South Africa, adopted in Brasilia (Brazil) in March 2015. The Memorandum on STI Cooperation established a strategic framework for BRICS cooperation in STI to address common social and economic challenges by co-generating knowledge and innovation and promoting international partnerships.

# HIGH-LEVEL MEETINGS

I BRICS STI Ministerial Meeting
South Africa, 10 February 2014.
Cape Town Declaration
**Theme: BRICS STI Cooperation: A Strategic Partnership for Equitable Growth and Sustainable Development**

The I STI Ministers Meeting discussed and coordinated positions of mutual interests and identified instruments of cooperation. The Meeting agreed with the text of the Memorandum on STI Cooperation as well as on the main STI areas of cooperation. The Ministers recognized the importance of information sharing and joint long-term programmes which may necessitate different kinds of support, including financial.

II BRICS STI Ministerial Meeting
Brazil, 18 March 2015.
Brasilia Declaration
**Theme: Inclusive Growth: Sustainable Solutions**

In order to foster further collaboration and achieve concrete results from the MoU directives, the Meeting agreed to develop and negotiate a Work Plan 2015-2018 to ensure the development of STI cooperation through the launch of a BRICS Research and Innovation Initiative, which covers actions including:

- cooperation in the framework of major research infrastructures;
- coordination of existing large-scale national programmes of BRICS countries;
- setting up a Framework Programme for funding multilateral joint projects for research, technology commercialization and innovation;
- establishment of a joint Research and Innovation Networking Platform.

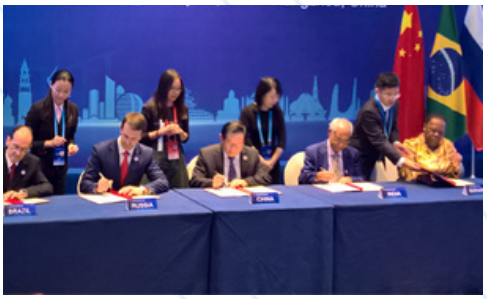

III BRICS STI Ministerial Meeting
Russia, 28 October 2015.
Moscow Declaration
**Theme: BRICS Science, Technology and Innovation Partnership – a Driver of Global Development**

The Meeting welcomed the establishment of Working Group on BRICS large research infrastructures and the Working Group on BRICS funding multilateral joint research projects, technology commercialization and innovation. To address common societal challenges and to advance BRICS leadership, Ministers enhanced the following initiatives:

- Creation of BRICS Young Scientists Forum (with Secretariat in India);
- Cooperation on Biotechnology and Biomedicine including Human Health and Neuroscience (Russia and Brazil as coordinating countries);
- Cooperation on Information Technologies and High-Performance Computing (China and South Africa as coordinating countries);
- Cooperation on Ocean and Polar Science and Technology (Brazil and Russia);
- Cooperation on Material science including Nanotechnology (India and Russia);
- Cooperation on Photonics (India and Russia).


IV BRICS STI Ministerial Meeting
India, 8 October 2016.
Jaipur Declaration
**Theme: BRICS Science, Technology and Innovation Partnership –Building Responsive Inclusive Collective Solutions**

STI Ministers welcomed the establishment of the BRICS STIEP WG. The main purpose of the Working Group is to exchange experience and best practices in ensuring the innovation strategy and policy of the BRICS countries, as well as to develop direct cooperation between the participants in the innovation chain. Also, the BRICS WG on Biotechnology and Biomedicine was endorsed.



V BRICS STI Ministerial Meeting
China, 18 July 2017.
Hangzhou Declaration
**Theme: Leading through Innovation & Deepening Cooperation**

Ministerial Meeting was focused on promoting exchanges and good practices among the BRICS countries on innovation strategies and policies, developing cooperation among science parks, encouraging technology transfer among the BRICS countries, strengthening training of technology transfer professionals and developing platforms for collaboration among businesses and academia. At the Meeting five BRICS countries adopted the BRICS Action Plan for Innovation Cooperation (2017-2020).


VI BRICS STI Ministerial Meeting
South Africa, 3 July 2018.
Durban Declaration
**Theme: Leveraging BRICS Science, Technology and Innovation to Enhance Inclusive Growth and Development**

Ministers reaffirmed the fundamental role of science, technology and innovation as key socio-economic change agents for global and regional progress along with growth and stability. They welcomed the establishment of the Integrated Hub for BRICS Innovation Collaboration on ICT and HPC.


VII BRICS STI Ministerial Meeting
Brazil, 20 September 2019.
Campinas Declaration
**Theme: BRICS: economic growth for an innovative future**

The VII BRICS STI Ministerial Meeting was held in Campinas (Brazil) in 2019. Pursuant to the implementation of the BRICS Action Plan for Innovation Cooperation, Ministers endorsed the Enabling Framework for the Innovation BRICS Network (iBRICS Network), elaborated by the STIEP WG. Also, the New BRICS STI Architecture was endorsed. To implement it, the Steering Committee was established.

# Structure and Management

## of the Memorandum on STI Cooperation

### THE MAIN GOVERNING STRUCTURES:

- BRICS STI Ministerial Meeting
- BRICS STI Senior Official Meeting
- BRICS STI Working Groups

### OPERATIONAL INSTRUMENTS:

- BRICS STI Framework Programme
- BRICS STI Work Plan 2015-2018
- Action Plan for Innovation Cooperation 2017-2020
- BRICS STI Work Plan for 2019-2022;
- New BRICS STI Architecture

As the principal mechanism, the Memorandum on STI Cooperation became a start for building consensual cooperation in STI based on the principles of voluntary participation, mutual benefit, equality and reciprocity. It is focused on:

- sharing and exchanging information of STI policies and strategies;
- leveraging contacts and programmes aimed at enhancing collaborative innovation projects; and
- the formulation of joint long-term cooperation programmes.

The Memorandum on STI Cooperation plays an important role in guiding overall cooperation.

sustainable agriculture

food security

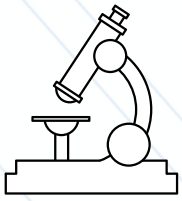
natural disasters

water resources and pollution treatment

new and renewable energy, energy efficiency

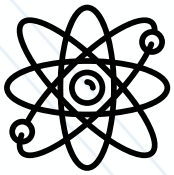
space research

geospatial technology



medicine and life sciences

new materials and nanomaterials



photonics

ICT

ocean and polar sciences

BRICS STI Framework Programme endorsed in 2015 (signed in 2016) was proclaimed to support research on priority areas and provide funding for multilateral joint research projects, technology commercialization projects and innovation projects.

The first three-years BRICS STI Work Plan was also adopted in 2015 at the STI Ministerial Meeting in Moscow as the operational instrument for achievement of the Memorandum on STI Cooperation and Strategy for BRICS Economic Partnership goals. In line with article 3 of the Memorandum on STI Cooperation, the Work Plan endorsed the initiatives and projects to be achieved by BRICS countries.

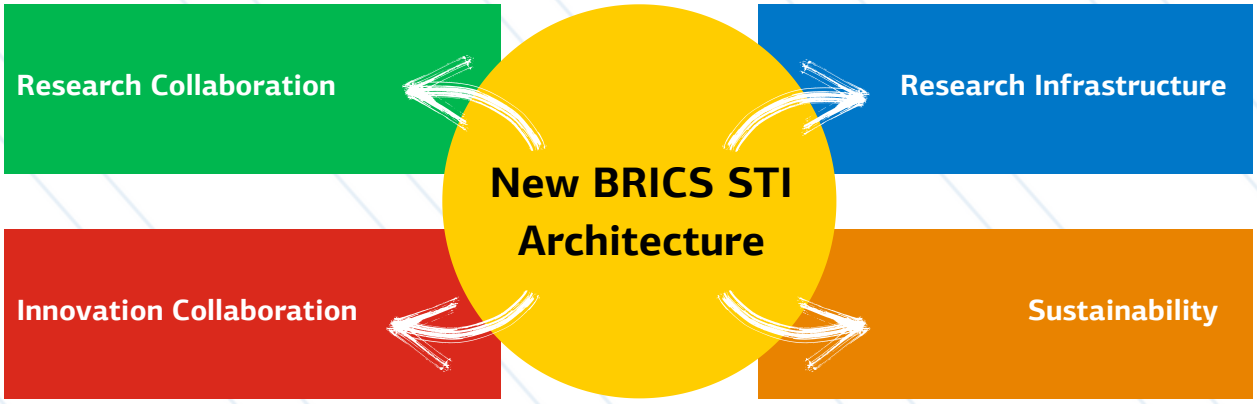
By 2017, by the three-years Action Plan for Innovation Cooperation (2017-2020) was endorsed. The document reinforces the pragmatic side of STI and encourages the creation of a favorable ecosystem for innovation and entrepreneurship. The Action Plan for Innovation Cooperation, for which the BRICS Science Technology Innovation and Entrepreneurship Partnership (STIEP) Working Group is responsible, has become a bridge between scientific and economic cooperation highlighting that innovation is one of the key drivers of global sustainable development.

In 2019, the BRICS STI Ministers adopted in Campinas (Brazil) the second BRICS STI Work Plan for 2019-2022. Considering the high number of initiated actions and projects, the paper is focused on the implementation of already existing activities. In line with the Work Plan revision logic, and following the decisions of the 6th BRICS STI Ministerial Meeting held in Durban (South Africa) in 2018, the New BRICS STI Architecture was presented by Brazil.

# New BRICS STI Architecture

The New BRICS STI Architecture embraces the Ministerial and Senior Officials meetings, activities of 13 working groups (WG), joint calls for research projects, BRICS YSF, Water Forum, BRICS Science Academies Meeting, Conference on Technology Foresight and STI Policy, the platform for research infrastructure collaboration, and the Action Plan for Innovation Cooperation.

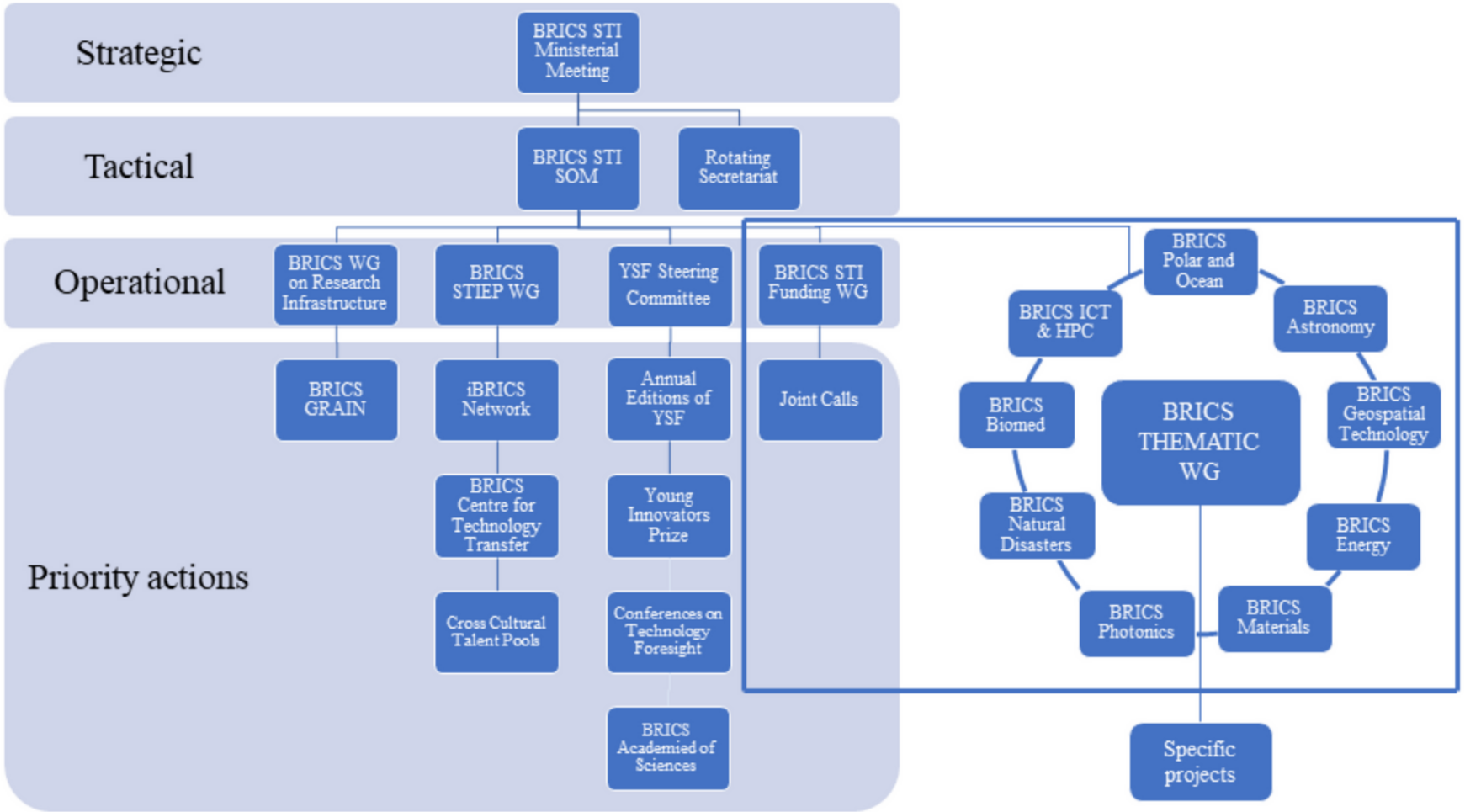
The New BRICS STI Architecture as well as the BRICS STI Work Plan for 2019-2022 subdivides the STI cooperation into four main pillars:




The main goals of the New BRICS STI Architecture are:

- to improve the coordination and management of BRICS STI activities through the simplification and rationalization of the cooperation governance structure;
- to organize the different actions of cooperation according to their level of priority, in order to concentrate Government efforts on the strategic ones, giving researchers and specialists the responsibility for running scientific initiatives;
- to ensure that the human and financial resources allocated by the five countries will be assigned to priority actions, giving them higher efficiency and effectiveness;
- to measure, monitor and evaluate STI activities and initiatives, in order to minimize their development risks to make them result-oriented and optimize their real impact to society; and
- to ensure wide and effective dissemination of information about BRICS STI activities amongst different stakeholders including policy makers, scientists, research organizations and a wider audience, including the development of the BRICS STI Cooperation website.

# BRICS STI New Architecture








In order to implement the New BRICS STI Architecture concept and support the main governmental bodies, the BRICS STI Steering Committee was established. The Committee institutionalized the virtual interaction of BRICS Focal points and STI Coordinators. The BRICS STI Steering Committee comprises ten rotating members appointed by the STI Ministry in each BRICS country (2 members from each country). The responsibilities of the Steering Committee include:

- monitoring the implementation of planning documents,
- support and coordination of joint calls,
- provision of information,
- analytical, organizational and technical support,
- provision for future activities.

## BRICS STI Steering Committee

The 1st Meeting of the Steering Committee was held in Moscow (Russia) in February 2020. The Meeting discussed the mechanisms of interaction between members of the STI BRICS Steering Committee and the key events in STI for the year that has begun.

One of the key topics of discussion was the structure of the created web platform designed to raise awareness of BRICS STI cooperation. The Steering Committee web platform is aimed at simplifying communication processes within the BRICS working groups and other bodies and structures of the BRICS STI framework.

# Research collaboration

The BRICS STI research collaboration is comprised of two main initiatives: the STI thematic working groups and the joint calls for research projects.

# BRICS WG

## on Biotechnology and Biomedicine including human health and neuroscience

http://brics.skoltech.ru/

The BRICS Working Group on Biotechnology and Biomedicine was established by the decision of the IV STI Ministerial Meeting in 2016 in Jaipur (India). The WG`s coordinators are Russia and Brazil.

The 1st Meeting of the BRICS Working Group on Biotechnology and Biomedicine was held in Moscow (Russia) in 2017. The delegates formulated the thematic directions for medicine, bio- and neurotechnologies in BRICS STI FP calls.

The Meeting also highlighted the need to initiate work related to the harmonization of national health information standards and regulations in order to enhance the sharing of large medical data sets in research, subject to the principles of privacy and national interests of all countries. The Terms of Reference of the Working Group was agreed.

The 2nd Meeting of the WG in Cape Town (South Africa) in 2018 discussed the establishment of the Center for Research and Development of Vaccines of the BRICS Countries, initiated by South Africa. The issue is coordinated by the relevant agencies and bodies of the BRICS countries within the framework of a separately created Working Group.

The 3rd Meeting of the BRICS WG took place in Campinas (Brazil). The group was focused on discussing and agreeing on priority topics for the area of Biomedicine and Biotechnology to be incorporated into the joint calls to support RD&I within the BRICS framework, debating topics such as advanced diagnostics and therapy (cell-therapy, omics, immuno-therapy, etc.), digital medicine and e-Health, antimicrobial resistance, drug repurposing and development of new drugs and vaccines to treat and prevent infectious diseases.

Among the main difficulties raised by the members of the WG are the need to increase interaction between its members between one meeting and another; the need to increase the dissemination of the WG activities; and the need to promote other forms of cooperation in the area of Biomedicine and Biotechnology.

As WG highlighted at the last Meeting, some ways to improve the group’s performance are:

a) to promote greater monitoring and follow-up of the WG's actions;

b) to implement other forms of support for BRICS projects (besides financial);

c) To promote side events to the WG meetings and to increase scientific integration between BRICS countries in areas related to the group's activities;

d) to create more space for the WG on the BRICS S&T online platform; and

e) to approach ICGEB in order to articulate a joint initiative.

The outbreak of the COVID-19 pandemic has increased demand for medicines, vaccines, diagnostics and reagents and may open up new avenues of cooperation for the WG and for the BRICS STI cooperation as a whole.

# BRICS OCEAN AND POLAR SCIENCE AND TECHNOLOGY WG

http://land-ocean.ru/brics/

The BRICS STI Ministers at their III STI Ministerial Meeting in October 2015 in Russia adopted the Moscow Declaration encouraging new initiatives, in particular, cooperation on Ocean and Polar Science and Technology.

The mission of the WG is to promote cooperation between BRICS member countries in the field of ocean and polar science and enabling technologies through joint activities in order to generate new knowledge, train human capital, develop new technologies and applications, and improve public understanding of ocean and polar science.

The 1st Meeting of the BRICS WG on Ocean and Polar Science and Technology was hosted by Brazil in July, 2018. It continued the work of the Workshop on Operational Oceanography held in China. Participants initiated the so-called BRICS expeditions. China invited experts from BRICS countries to join the upcoming expedition in the South Atlantic.

The 2nd Meeting of the WG was held in Russia. India offered to provide 2-3 positions for researchers from BRICS countries on India's research vessels and on the Antarctic stations in 2020.

South Africa and Russia welcomed BRICS experts to participate in expedition of a Russian ship to the Southern Ocean. There were several joint expeditions with the participation of Brazil and Russia: to the Black Sea (2016, 2017), to the South Atlantic (2017), to Issyk-Kul Lake (2018), to the Caspian Sea (2019).

On 23 September, 2020, the BRICS Ocean and Polar Science and Technology WG held its 3rd Meeting via videoconference under Indian chairmanship. The focus of the discussion was on plastic and microplastic pollution of the seas and oceans, as well as changes in the world's oceans and global climate.

The delegations discussed the joint use of research vessels for studies and expeditions, and amendments to their agreements due to the COVID-19 pandemic. In particular, they discussed plans to send an expedition to the Amazon River plume in the equatorial Atlantic Ocean to study the influence of the world's largest drainage basin on the balance of biogenic emissions and pollutants in the ocean and its physical and chemical systems. The participants reaffirmed their intention to organize special subject courses and summer schools for young scientists from the BRICS countries.

They also discussed the possibility of cooperation within the framework of the UN Decade of Ocean Science for Sustainable Development (2021-2030) aimed at mobilizing the scientific community, responsible politicians, businesses and civil society to implement a programme of joint studies and technical innovations.

# BRICS GEOSPATIAL WORKING GROUP

The BRICS Geospatial Working Group was established in 2015 by the Moscow STI Ministerial Declaration.

The 1st WG Meeting was held in Noida (India) in 2016. The participants of the Meeting discussed national strategies of geospatial cooperation and identified common areas of interest.

In January 2017, India hosted the 2nd Meeting of BRICS Geospatial Working Group. It was suggested to create a platform for the exchange of knowledge in the field of geospatial technologies on the basis of the existing web portal iGET (India). The 3rd Meeting of the group is planned for 2021 in Brazil. The Geospatial Working Group works in strong collaboration with the Working Group on Prevention and Monitoring of Natural Disasters.

Installed Engine Noise Attenuation (IENA), joint cooperation project in the field of aeroacoustics, TsAGI (Russia), the Aerodynamic Research Institute AVIC (ARI, China), the Federal University of Santa Catarina (UFSC, Brazil), BRICS Framework Programme 2019

The geospatial ecosystem is evolving fast, as a result, huge demands have been generated for Geospatial technology, which has forayed across various sectors in the public as well as private domain in BRICS. As stakeholders across sectors realize the utility and long-term cost effectiveness of using geospatial tools and technologies, the geospatial industry is set to progress by leaps and bounds in the coming years [3]. Currently, the overall size of Indian Geospatial Industry is $4 billion and by 2025 it is estimated to contribute $20 billion (5 percent of the total GDP). India's National Mission on Digital India provides opportunity to establish end to end geo-spatial electronics delivery systems as part of Mission Mode Projects in the eGovernance domain. India is committed to implement the Sustainable Development Goals (SDGs). Geospatial information provides the backbone of the 232 indicators for this purpose. For this purpose, India provides the leadership in the Geospatial Working Group to provide the BRICS member nations the benefits of developing Geospatial Policy, National Spatial Data Infrastructure and building capacity in Earth Observation Applications, especially in the areas of Agriculture, Disaster Risk Reduction, Smart city and land management. The BRICS collaboration will help in technology sharing and exchange of technical personnel and networking among the researchers and relevant research organizations.

[3] Report of FICCI Task Force on Geospatial Technologies

# BRICS PREVENTION AND MITIGATION OF NATURAL DISASTERS

# MONITORING & EARLY WARNING

The BRICS WG on Prevention and Mitigation of Natural Disasters – coordinated by Brazil – was established in line with the BRICS MoU on STI Cooperation and following the outcomes of the Moscow STI Ministerial Declaration of 2015.

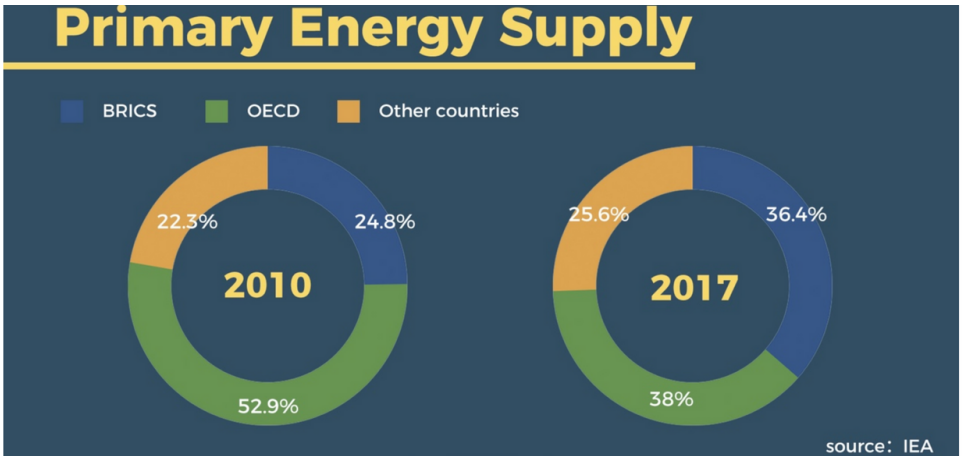
The 1st Meeting of the WG took place during the sixth Annual Conference of the International Society for Integrated Disaster Risk Management hosted by India in October 2015 in New Delhi (India).

The 2nd Meeting of the WG on Natural disaster risk prevention and Mitigation was held in Coastal Areas jointly organized by Russia and Brazil in Saint-Petersburg (Russia) in August 2016. The Meeting acknowledged the need for continuous technological and innovative scientific problem formulation and framework to understand priorities and directions for prevention and mitigation of Natural Disasters for all the BRICS countries.

Disaster Risk management is based on several pillars. The most known and popular is response. Every recovery, humanitarian and emergency aid work is based on this pillar. However, at the other end of the system, a pillar can mitigate the disasters` impacts, which is S&T and its warning system. Early warning, which enables actions of Civil Defenses for pre-disaster preparedness activities, is only possible through knowledge of the physical processes that trigger disasters. Thus, sharing the State of the Art of Disaster Science with the international scientific community is essential for rapid and significant advances. It is now considering to join forces with the Disaster Management Ministries. The issue is to be discussed during the 3rd WG Meeting in Brazil in 2021 which will be held in parallel with the BRICS Geospatial WG.

# BRICS WORKING GROUP ON NEW AND RENEWABLE ENERGY

Energy efficiency has been high on the agenda of the BRICS group of countries. BRICS countries also account for 36 percent of the global primary energy supply and this share may surge by almost 50 percent by 2040 [4]. This allows the block to wield tremendous influence over the future of the global clean energy transition as they play a crucial role in the world economy and energy market.




China hosted the 1st Meeting of the BRICS Working Group on New and Renewable Energy in December 2017. Parties presented national reports in terms of the development of new and renewable energy in each BRICS country. All participants agreed that new and renewable energy has a prioritized position in the energy strategy for each BRICS country. There are plenty of reasons:

- safe and reliable energy supply,
- clean and sustainable development, addressing climate change,
- poverty relief etc.

At the same time there is a need in forecasting volumes of energy resources production and their consumption by industrial and communal systems of different levels: building, town, city, region, country. Participants decided to establish databases in order to help researchers to find partners, resource match and explore the possibility of establishing a BRICS New Energy and Renewable Energy Center to form a network to coordinate the actions intersessionally.

The 2nd Meeting of the Working Group took place in October via a videoconference under the Russian BRICS Chairmanship in 2020. The need to allocate one joint publication per year in BRICS countries peer-reviewed journals or books was highlighted.

The 3rd Meeting of the BRICS Working Group is scheduled in India in 2021.

[4] according to the International Energy Agency (IEA)

# BRICS SSL WG

The BRICS STI Work Plan 2015-2018 envisages the decision to develop direct communication channels between STI stakeholders including Solid-state lightning as a sub-area of Energy efficiency. The topic is being led by China. Since the 1st WG Meeting, which was held in November 2015 in China, the SSL WG has been holding meetings annually. So far, the SSL WG has held 17 conferences, 20 seminars and visited 20 enterprises in total.

At each meeting of the SSL WG, representatives of the science and technology departments of the BRICS governments and industry introduce their national SSL development strategies and related policies in the near and medium term, including the related content about promoting the development of SSL in the strategic emerging industries and energy policies; SSL technology innovation policy, related development planning, financial subsidies and incentive measures; the functions among government, enterprises, research institutes, non-governmental organizations and other stakeholders in the activities of promoting the development of SSL. This kind of exchange and information sharing provides an effective reference for participants on BRICS SSL technology innovation, policy formulation and industrial development regarding SSL.

In addition to dialogue and collaboration in the field of SSL generic technology R&D and cutting-edge applied innovations, exchanges and cooperation have been carried out particularly in smart lighting and smart cities, standardization, SSL in agriculture (lighting for growing plants, intelligent poultry farming lighting), health lighting, Micro-LED, OLED, landscape lighting design technology innovation and other fields.

## The SSL WG organizes the meetings in a BRICS+ format inviting observers from Rwanda, Malaysia, Belarus, Thailand, Vietnam and Myanmar

The 1st Meeting of BRICS and BRICS + Countries on SSL International Standardization was held during the Sixth Meeting of BRICS SSL Working Group.

The basic contents, formulation procedures and organizational systems of both global and BRICS SSL standards were communicated in this Meeting. The released standards of ISA Technical Committee of Standardization (TCS) were distributed at the request of participants. The meeting promoted the process of SSL standards development in BRICS countries.

The Secretariat and BIS collaborated on SSL accelerated tests and on standard nterface specification demonstration.

It is suggested that 8 technology innovation cooperation groups would be established under the WG framework i.e. smart lighting, agricultural lighting, health lighting, UV LED, Micro-LED, LiFi, reliability test and off-grid solar lighting.

Each group is composed of researchers, experts and scholars recommended from each member state for the purpose of carrying out in-depth cooperation in these fields to meet the actual needs of technology innovation and development of each member state.

It is also considering to carry out cooperation and exchanges in R&D and technology innovation on SSL through the BRICS Technology Transfer Center.

# BRICS Astronomy WG

https://www.bricsastronomy.org/

The main aim of the BRICS Astronomy Working Group (BAWG) is to exploit the basic strengths for the mutual betterment of the general population amongst the BRICS member countries. This is done through developing astronomical sciences, generating new knowledge, training human capital, developing new technologies and applications, and improving public understanding of science.

To date a total of five BAWG meetings have been held, starting with the Inaugural Meeting in Cape Town (South Africa) in 2015, the 2nd in Ekaterinburg (Russia) in 2016, and the 3rd one in Pune (India) in 2017, the 4th one in Durban (South Africa) in 2018 and the 5th one in Rio de Janeiro (Brazil) in 2019. During these five years, the BAWG managed to achieve the following:

- the Terms of Reference for the BAWG was adopted and it defines the mandate, scope of work and roles and responsibilities of each party;
- a strategic plan was developed and adopted – it is called the 2017-2020 BRICS Astronomy Framework for Scientific Cooperation, and it defines the priority areas of cooperation and the modalities of engagement.

The priority science areas identified include but are not limited to cosmology, galaxy formation and evolution, stellar and compact object astrophysics, and big data.

At the Meeting held in Rio de Janeiro (Brazil) in 2019 it was agreed that the BAWG will work on one joint flagship project known as the BRICS Intelligent Telescope And Data Network. The proposed project will be led by South Africa as the main principal investigator with other member countries forming part of the team of principal investigators. On 24th and 25th September, the 6th Meeting of BRICS Astronomy Working Group took place via videoconference. The event was attended by over 70 experts from BRICS countries. The Meeting participants discussed prospects for implementing the BRICS Intelligent Telescope and Data Network project and the establishment of a BRICS Centre for Observation Data Processing.

Under the project, in 2021, the countries plan to start assembling a prototype distributed network of large-area telescopes based on the infrastructure available to academic organizations in the BRICS countries. The implementation of the first phase of the project is believed to help form scientific and organizational ties, train staff members and start developing the necessary equipment and software for its main phase.

# The BRICS Intelligent Telescope and Data Network (BITDN)

At the 5th annual BAWG Meeting representatives from the BRICS countries agreed to develop a Flagship project taking advantage of the combined scientific, technological and engineering expertise of the BRICS member states to meet these challenges and provide a world-class facility for astronomical research.

The BRICS Intelligent Telescope and Data Network (BITDN) is a collaborative scientific enterprise, drawing on the strengths of all five BRICS partners, while at the same time seeking to address in-country socioeconomic development challenges. The Flagship scientific programme will develop a network of astronomical telescopes, some already existing, and an associated intelligent data network which is the enabler for the science programme. This will leverage existing and planned new telescope and cyber facilities within the BRICS countries and will also draw on the opportunities presented by other multi-wavelength space- and ground-based facilities within, or accessed by, the BRICS countries.

Thanks to their unique, worldwide geographical distribution, BRICS countries are well placed to take a global lead in the rapidly expanding domain of wide-field multi-wavelength imaging sky surveys and the detection and study of transient and time-variable phenomena in the Universe, as well as technical solutions to the associated enormous Big Data and Big Compute challenges. This ambitious plan for a global network of optical telescopes, with the unprecedented ability to observe the entire sky continuously on a timescale of less than an hour, will greatly increase our ability to monitor the changing cosmos.

In 2021, it is planned to begin the creation of a prototype of a distributed network of wide-angle telescopes, as well as an observational data processing center. It is assumed that the implementation of the first part of the project will create scientific and organizational ties, train personnel and start developing the necessary equipment and software for the main phase of the project.

Because of the epidemic situation, the 6th BAWG Meeting as well as the annual seminar were held in a video-conference format. The leading scientists and engineers from the BRICS countries devoted their reports to the project implementation and discussed further steps for the implementation of this project.



[3] Information is taken from the BAWG official web-site

# BRICS WG ON MATERIALS SCIENCE AND NANOTECHNOLOGY

The collaboration in Materials Science and Nanotechnology has progressed well over the years. It is one of the most sought-after areas for BRICS collaboration, and more than 20 projects were supported under three BRICS Calls.

During the 1st WG Meeting which was held in Yekaterinburg (Russia) in October 2017, participants discussed the creation of the Network Centre for Materials Science and Nanotechnology of the BRICS countries.

On 1st and 2nd October, 2020, under the chairmanship of India the BRICS WG on Materials Science and Nanotechnology held its 2nd Meeting via videoconference. The participants agreed on the concept for the BRICS Network Centre for Materials Science and Nanotechnology, initiated by Russia in 2017.

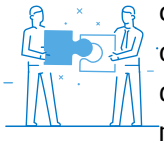
This concept sets forth the goals and objectives for creating the Centre, as well as how universities and research institutions can become part of it. The Ural Federal University named after Boris Yeltsin (UrFU) will serve as the parent organization of this virtual centre, providing for its secretariat and website and taking care of organizing in-person or online meetings of the Centre's Council twice a year. Working Group participants also outlined the key areas of materials sciences that the BRICS countries should focus on. Each of the BRICS countries will oversee one or several subjects.

In addition, the Meeting participants approved the Terms of Reference of the WG on Materials Science and Nanotechnology, which sets forth its goals, objectives, functions and procedures. Within BRICS, Russia and India are in charge of coordinating this working group and ensuring its operation.

# Objectives of Virtual Centre – BRICS Network Centre for Materials Science and Nanotechnology (NCMSN)

The NCMSN`s main goals include promoting international cooperation and identifying priorities for joint research projects by the participating countries on materials science and nanotechnology, as well as fundraising and attracting support from public and private sources for promoting research, technology and innovation. In addition, the Centre is expected to host thematic international research conferences and seminars, as well as to create a website on its activities and participants. The leading BRICS universities and research institutions on materials science and nanotechnology, which share the Centre's goals and objectives and are ready to contribute to joint programmes and events in multilateral and bilateral settings, can join the centre.

BRICS-NCMSN aims to:



combine the efforts of leading institutions of the BRICS countries to produce highly qualified personnel in the fields of materials science and nanotechnology and to facilitate the academic exchange of students, teachers and scholars of the BRICS countries for research and training purposes;

identify the most promising areas of basic and applied research and development in the field of materials science and nanotechnology;

enhance the scientific and technical cooperation of the BRICS countries in the field of materials science and nanotechnology;

promote research leading to innovation-based economy, wealth generation and employment opportunities; and

promote interactions between academia, private sectors and entrepreneurs.

# BRICS Virtual Institute of Photonics

There has been two meetings of the Working Group on Photonics which were held in March 2018 in Russia and in October 2020 via videoconference under the Russian BRICS Chairmanship in 2020

https://virtualinstitute.info/

The creation of the BRICS VIP was approved by the STI Ministers in 2018 during the Meeting in Durban (South Africa). It was decided that Russia would be the coordinator of the BRICS VIP. The crucial mission of the BRICS VIP is to be an effective instrument for the coordination of BRICS photonics-related activities, including coordination and management of training programmes (including extra-professional programmes for industrial partnership); providing information on the latest achievements in Russia and other BRICS countries in the area of photonics. The main tasks of the BRICS VIP are:

- to integrate, manage, coordinate, and monitor research projects in the field of Photonics in the frame of BRICS;
- create and manage R&D cooperative programmes in the field of Photonics for BRICS countries;
- establish and manage training programmes (including MS, PhD, and extra-professional training programmes for industrial partners);
- provide information on the latest achievements in Photonics;
- transfer new technology in the field of Photonics to industry;
- offer advice and services related to Photonics to industries, producers, distributors, potential users, service suppliers in BRICS countries and to the like in Europe and worldwide.

The BRICS VIP operation is supported by the Skolkovo Institute of Science and Technology.

# BRICS WORKING GROUP ON ICT AND HPC


In April 2017, China hosted the 1st Meeting of BRICS Working Group on ICT and HPC.

The Working Group on ICT and HPC is aimed at achieving substantive outcomes under the BRICS STI Framework Programme in the areas of significant impact on globally challenging issues such as industrial restructuring and upgrading, intelligent manufacturing, healthcare delivery, precision farming, pollution control, the development of smart cities and other areas. Specifically, the WG has recommended the creation of a BRICS Innovation Collaboration Flagship Project on ICT and HPC with commitment of funds at a level of 5 million USD or more per member state over a period of five years. The five topics have been identified by the 1st WG Meeting in 2017 and reconfirmed by the 3rd WG Meeting in 2019 as a possible flagship project, including:

1. Digital Smart Manufacturing;
2. HPC application for Life Sciences, Precision Medicine and Public Health;
3. Integrated Precision Farming;
4. Large Scale Multi-Agent based Simulation of Virtual Society;
5. Digital Earth Modeling.

Furthermore in 2017, the WG recommended to establish an integrated and cyber-secured ICT and HPC infrastructure such as a BRICS Innovation and Collaboration Cloud (BICC) to enhance and accelerate BRICS innovation collaboration. In doing so, China submitted a proposal in 2018 to the VI BRICS STI Ministerial Meeting for the establishment of an Integrated Hub for BRICS Innovation Collaboration on ICT and HPC. It was adopted into the Durban Declaration and BRICS STI Work Plan (2018-2019) as a major outcome of the Meeting. Subsequently China and South Africa jointly drafted a work plan for preparation of the Integrated Hub, and reported it in the 2nd WG Meeting in May 2019. After a lengthy discussion, a task force composed of representatives of each of the BRICS countries was established.

The WG is now focused on projects to support the battle against the outbreak of COVID-19 and the mitigation of its impacts which was discussed during the 4th WG Meeting.

# Integrated Hub for BRICS Innovation Collaboration on ICT and HPC

https://www.brics-ict-hpc-hub.org/42.html

According to the Durban Declaration, the BRICS STI Ministers welcomed the idea of establishing an integrated Hub for BRICS Innovation Collaboration on ICT and HPC.

The integrated Hub initiative was simultaneously discussed by the 3rd Meeting of the BRICS Working Group on ICT and HPC. Since July 2019, the Secretariat Office has started to develop an interactive website to serve the information exchange about researchers, funds, projects, research facilities and platforms available initially in China and later in other BRICS countries. It will be an Information Gateway Center for BRICS users to access HPC and other research facilities in China. The Website and Gateway Center of the Integrated Hub was launched for a trial run. It includes public resource and a news center with commercial resources and market place.

The 4th Meeting of the BRICS Working Group on ICT and HPC will discuss and formulate a Flagship Project and a series of normal projects to support the battle against the outbreak of COVID-19 and the mitigation of its impacts. It is necessary to include the establishment of an Integrated Hub and BICC for BRICS Innovation Collaboration on ICT and HPC as a part of the Flagship Project to support its missions. The 4th WG Meeting will prepare a recommendation document to be reported to the SOM for a decision of the Action Plan for Innovation Cooperation. Under the framework of the Flagship Project, the integrated Hub will organize regular events such as BRICS Innovation Collaboration Forum International Symposium or Workshop; coordinate adequate resources such as matching funds, expertise, software library, databases and HPC resources as well as a startup fund for carrying out pilot BRICS joint research projects; network Micro-Small-Medium enterprises (MSME) and facilitate technology transfer and commercialization.

# BRICS STI FRAMEWORK PROGRAMME

http://brics-sti.org/

In July 2015, Russia hosted the 1st BRICS STI Funding Parties Meeting aimed to introduce the BRICS Research and Innovation Initiative for multilateral research funding. The Meeting agreed to develop and implement the BRICS Framework Programme for funding multilateral joint research projects, technology commercialization and innovation.

The 2nd Meeting of the BRICS STI Funding Parties was held in Beijing on 19-21 January, 2016. BRICS countries reached consensus on the Arrangement of BRICS STI Framework Programme and its Implementation Plan. It was decided to initiate the pilot call in 2016.

## FUNDING ORGANIZATIONS

National Council of Brazil for Science and Technology Development
Brazil's Innovation Agency

Ministry of Science and Higher Education of the Russian Federation
Russian Foundation for Basic Research (RFBR)

Department of Science and Technology of India

Ministry of Science and Technology of China
National Natural Science Foundation of China

National Research Foundation
Technology Innovation Agency of South Africa

The coordination of call initiatives to support basic and applied research projects is carried out by the BRICS STI Call Secretariat, represented by RFBR. To optimize the work and simplify the procedure of handing in joint applications, a web portal for the BRICS STI Framework Programme was developed by the BRICS STI Call Secretariat.

In 2019, the BRICS STI FP 3rd Call was conducted and the first cycle of the BRICS STI Framework Programme was finished. According to RFBR statistics, the outcome of the third call was the support of 35 projects – the largest number of projects since the launch of the BRICS STI Framework Programme.

As the result of three BRICS STI Framework Programme coordinated calls, 93 projects were supported in 11 research areas. The areas of high scientific interest were material science and biomedicine.

The procedures of the second stage of the BRICS STI Framework Programme should be modified aiming at overcoming the administrative barriers, synchronization of national terms and procedures, involvement of thematic WGs in call topics selection. The new principles developed within BRICS STIFP will set up the basis of implementing the second cycle of BRICS STIFP scheduled for 2020-2024.

# COORDINATED CALLS FOR BRICS MULTILATERAL RESEARCH AND INNOVATION PROJECTS

## 2016 BRICS STI FP PILOT CALL

The participating funding organizations invited researchers from their countries to identify potential partners in at least two other BRICS countries and to jointly prepare proposals for cooperative research projects in the thematic areas of the call.

The call was announced in May 2016. Collaborative multilateral basic, applied and innovation research projects in 10 thematic areas could be submitted in response to the call:

- Prevention and monitoring of natural disasters
- Water resources and pollution treatment
- Geospatial technology and its applications
- New and renewable energy, and energy efficiency
- Astronomy
- Biotechnology and biomedicine including human health and neuroscience
- Information technologies and high performance computing
- Ocean and polar science and technology
- Material science including nanotechnology
- Photonics

The Call generated great interest among the BRICS research communities with 320 proposals submitted in response to the Call. 26 projects in 10 thematic areas have been selected for support as an outcome of the call.




## 2017 BRICS STI FP SECOND CALL

South Africa hosted the 3rd BRICS STI Funding Working Group Meeting for discussion and negotiation on the approval of the first set of joint projects:

The call focused on six thematic areas:

- Material sciences including nanotechnology;
- Biotechnology and biomedicine including human health and neuroscience;
- Water resources and pollution treatment;
- New and renewable energy, and energy efficiency;
- Information technologies and high performance computing; and
- Prevention and monitoring of natural disasters.

462 proposals were submitted for consideration. 32 projects in 6 thematic areas have been selected for support as an outcome of the call.

## 2017
## BRICS STI FP
## THIRD CALL

The 4th Meeting of the BRICS STI Working Group on Funding took place in Durban (South Africa) in June 2018. The Meeting once again discussed the importance of a centralized procedure for project submission and evaluation.

The 5th Meeting of the BRICS STI Funding Working Group took place in Campinas (Brazil) in September 2019. The main issues on the agenda of the Meeting was the discussion on the 3rd BRICS STI Call 2019. The call was focused on 13 thematic areas for which 331 proposals were submitted for consideration. The most frequent thematic area of the proposals submitted were:

- Material science including nanotechnology - 122;
- New and renewable energy, and energy efficiency - 45;
- Water resources and pollution treatment - 37;
- Biotechnology and biomedicine including human health and neuroscience - 33;
- Prevention and monitoring of natural disasters - 32.

33 proposals were selected for funding based on the evaluations and funding available. Two additional projects (New and renewable energy, and energy efficiency; Prevention and monitoring of natural resources) were also selected with the condition that the respective PIs secure their own funding.

The interest in the BRICS STI Framework Program is rapidly increasing within the BRICS scientific community since its foundation. It garners strength due to stable funding committed by all the five countries. The Pilot Call 2016 had 320 proposals submitted in 10 priority areas. The 2nd BRICS Call 2017 had 462 proposals submitted in 6 priority areas. The number of submitted applications has increased by 45%. However, in the 3rd BRICS Call 2019, 331 proposals were submitted in 13 priority areas.

# Response to the COVID-19 pandemic coordinated call for BRICS multilateral projects 2020

In response to the COVID-19 pandemic, the BRICS STI Framework Programme is launching a call for multilateral basic, applied and innovation research projects facilitating cooperation among the researchers and institutions in the consortia which consist of partners from at least three BRICS countries corresponding to the following thematic areas:

1. Research and development of new technologies/tools for diagnosing COVID-19.
2. Research and development of COVID-19 vaccines and drugs, including repurposing of available drugs.
3. Genomic sequencing of SARS-CoV-2 and studies on the epidemiology and mathematical modeling of the COVID-19 pandemic.
4. AI, ICT and HPC oriented research for COVID-19 drugs design, vaccine development, treatment, clinical trials and public health infrastructures and systems.
5. Epidemiological studies and clinical trials to evaluate the overlap of SARSCoV-2 and comorbidities, especially tuberculosis

# Research infrastructure

# BRICS GRAIN

since 2016 and counting

http://brics-grain.org/

## MAY 2017

The kick-off Meeting of the BRICS Working Group on Research Infrastructure and Mega-Science Projects was hosted by Russia in May 2017, and was focused on BRICS GRAIN development.

The main goals of the Working Group on Research Infrastructures and mega-science projects are:

- to promote cooperation within large-scale research infrastructure;
- to support initiatives leading to efficient use and development of mega-science projects in the BRICS countries thus contributing to the implementation of the BRICS Research and Innovation Initiative;
- to create a dynamically developing complex of Research Infrastructures amongst BRICS member countries to provide fundamental and applied task solutions on the cutting-edge of science; and
- to engage the global research community to the BRICS Research Infrastructures.

BRICS GRAIN is one of the main initiatives of the BRICS Working Group on Research Infrastructure. It includes existing research infrastructure objects as well as the developing research infrastructures of BRICS countries. The platform created under the Russian initiative is intended to raise the awareness of the global community to the mega-science projects, implemented within the framework of BRICS STI Cooperation on the research infrastructures of BRICS countries by joint forces, fostered and developed by scientists and researchers from Brazil, Russia, India, China and South Africa.

## MARCH 2018

The 2nd Meeting of the BRICS RI WG was hosted by Brazil. It was agreed to establish a task force led by Russia, comprised of representatives of all BRICS countries, to implement the web portal. The members of the Working group recognized the need to develop a Strategic Plan on RI coordination. South Africa agreed to lead this process and to submit a draft to the other members of the WG. The participants highlighted the importance of researcher mobility, the organization of workshops, visits and joint projects that would involve the global research advanced infrastructures of the BRICS countries and the need to explore funding possibilities to support these activities.

# BRICS GRAIN

since 2016 and counting

## DECEMBER 2019

The 3rd Meeting of BRICS WG on Research Infrastructure and Mega-science Projects was hosted by China. One of the initial agenda points at the Meeting was dedicated to updates on countries' RI policies. The participants agreed to update the membership of the Working Group. Joint Institute for Nuclear Research (Russia) will continue the development and hosting of the BRICS GRAIN web platform. The countries reconfirmed the decision of setting the Task Force (or several Task Forces if needed). The WG agreed to start the preparation of drafting the Strategic Plan. China and Russia will coordinate the activities of the WG until the 4th Meeting.
The 4th Meeting of the BRICS Working Group on Research Infrastructures and Mega-science projects is to be held in Russia in 2020.

The activity of the RI WG is considered to be important and relevant to all BRICS countries. The BRICS GRAIN web platform provides information and the list of available research opportunities for BRICS scientists. BRICS GRAIN should become a single-entry point for potential Research Infrastructure Users and Partners: RI objects info, access/partnership policy and contacts. The five countries already announced some of their large research infrastructures that are available for collaboration, but more detailed information as well as more research infrastructures are needed to conclude the final version.

# Innovation Collaboration

Given the achievements so far in the research area, the next task should be the implementation of the BRICS Action Plan on Innovation Cooperation 2017-2020, adopted in Hangzhou, in July 2017 and signed under the witness of five BRICS leaders in Xiamen, in September 2017

# BRICS STIEP

and the key projects under its framework

**OCTOBER 2016**

The Jaipur Meeting of STI Ministers welcomed the establishment of the BRICS STIEP.

**APRIL 2017**

India hosted the 1st Meeting of the STIEP.

**JULY 2018**

The Durban Meeting of STI Ministers welcomed Brazil's proposal to establish the BRICS networks of science parks, technology business incubators and SMEs, and China's proposal to establish a BRICS Technology Transfer Center under the direction of the BRICS Science, Technology, Innovation and Entrepreneurship Partnership (STIEP) Working Group.

**SEPTEMBER 2018**

China hosted the 2nd Meeting of the BRICS STIEP. The Executive Plan of BRICS Technology Center 2018-2020 was presented by China. The Center is to enable mechanisms for collaboration between business incubators, accelerators and other participants of innovation chains, and technology transfer.

Brazil introduced the Enabling Framework for the Innovation BRICS Network (iBRICS) initiative aimed at the creation of mechanisms for the direct exchange of best practices between science and technology parks, incubators, accelerators and other innovative organizations of the BRICS countries.

**MAY 2019**

The 3rd Meeting of the BRICS STIEP hosted by Brazil elaborated the Enabling Framework for the iBRICS and ratified that the technology transfer center in Kunming (China) is to be the first step for building a BRICS network.

**OCTOBER 2020**

The 4th BRICS STIEP WG Meeting adopted the concept Enabling Framework for the BRICS Centers for Technology Transfer Cooperation (BRICS Techtransfer).

**The iBRICS Network is to be a mechanism for direct dialogue among the actors of innovation in the BRICS countries, which will promote mutual support, joint projects and the exchange of best practices with a view to advancing BRICS systems of innovation.**

## iBRICS was endorsed at the BRICS STI Ministerial Meeting in Campinas, in September 2019

A. Fostering dialogue and mutual knowledge. The network will be sought to build and implement information sharing mechanisms, such as online platforms, that can be efficient and flexible:
1 Provide information on each Member's facilities, soft-landing programmes, cross-incubation programmes, business models and product features to facilitate the identification of potential partners for research and development of new technology-based solutions;
2 Provide information on members` plans and initiatives towards expanding activities to new markets inside or outside BRICS to foster the establishment of international partnerships;
3 Foster cooperation among Members in priority-setting, collaborative opportunities, projects, and best practices;
4 Offer, where appropriate, opportunities of engagement with investors, businesses and industries inside and outside the iBRICS Network.

B. Capacity-building. The network will be sought to make the necessary efforts to organize joint-training courses for managers and specialists of science parks, technology incubators and accelerators of the BRICS countries, by means of:
1 Discussions on management issues to share the best business models and strategies among BRICS markets;
2 Modules of training and immersion in each BRICS country's market;
3 The dissemination of insights on the most critical innovation needs;
4 The exchange of expertise on identification, promotion and the use of available platforms for collaboration.

C. Cross-incubation. The network will be sought to facilitate the access of residents to science parks, incubators and accelerators from one BRICS country to the others, in order to:
1 Foster international technology partnerships for the development of new products, services and solutions, which match the needs of the BRICS countries industry and society;
2 Foster the incubation of startups among the BRICS countries of different business niches to diversify strategies for accelerating technology-based businesses;
3 Boost the exchange of experiences among Intellectual property-intensive companies, helping the proliferation of patents, trademarks, industrial design registrations, plant variety rights, copyright, geographical indications and industrial secrets among BRICS countries;
4 Encourage members to showcase their technology-based products, services and solutions to investors and investment funds of the BRICS countries.

D. Soft-landing. The network will be sought to facilitate the transnational establishment of high-tech companies in the member countries by:
1 Working in partnership with local governments to build fast-track bureaucratic processes for the local establishment of BRICS startups;
2 Fostering partnerships with local companies to allow access to national markets;
3 Encouraging partnerships with local investors to provide access to national credit funds;
4 Making efforts to open intra-BRICS lines of credits for the internationalization of BRICS startups.

# Sustainability

long-term
cooperation



# BRICS YOUNG SCIENTIST FORUM

https://www.brics-ysf.org/

**The key tasks of the BRICS YSF are:**

(1) To provide a platform for connecting & networking amongst the BRICS youth in order to harness their knowledge for resolving common societal challenges through research and innovation.
(2) To build BRICS leadership in S&T through the creative youth with capacity and capability to accelerate change individually and collectively (BRICS Youth Alumni).
(3) To reinforce BRICS nation's and regional STI policies, youth policies, skills development and entrepreneurship policies.

The annual BRICS YSF, which has been held five times, has become an important area to stimulate new academic ideas and train young professionals.

Since 2018, the Young Innovators competition with cash prizes was established within the framework of the BRICS YSF. The competition is the identification, rewarding and special recognition of young talented entrepreneurs and scientists, whose outstanding innovative projects are capable of making a significant contribution to the socio-economic environment and improving the living conditions of the populations in the BRICS countries. The BRICS Young Innovator Prize is aimed at both enabling the international environment to demonstrate the ability to take distributive ideas, and offering the opportunity for youth with the right mindset to contribute in the upliftment of BRICS communities. This is sometimes seen as a threat to the rest who cannot appreciate the role of innovation and entrepreneurship in socio-economic growth.

# BRICS WATER FORUM

The idea of holding BRICS Water Forums was the answer to the commitment to enhance cooperation in the field of water resources on the basis of sustainable development in an integrated way, addressing the themes of water access, flood protection, drought management, water supply and sanitation, water and climate, systematically facilitating water pollution prevention and control, river and lake ecosystem restoration and preservation, ecosystem conservation, and water resources management. The 1st BRICS Water Forum was held in September, 2016 in Russia.

One of the key goals of the BRICS Water Forum is the establishment of a common water resources community of researchers and experts working in BRICS countries; and the identification of existing capacities to undertake joint research and development, as well as technology transfer to address the needs of the water sector and the related sectors. BRICS Water Forum unites leading scientists and researchers in the area of water resources from BRICS countries and is a good platform for presenting and discussing sustainable water use and management solutions.

The strategic area of Water Resources and Pollution Treatment was added for the 3rd Call for Proposals of the BRICS STI Framework Programme. The activity of this collaboration platform is relevant to all BRICS countries. It is a viable platform for sharing the existing opportunities to undertake joint research and development, as well as technology transfer to address the needs of the water and related sectors.

# BRICS ACADEMIES OF SCIENCE

The aim of Academies networking is to drawn on and support the Memorandum on STI Cooperation by providing evidence-based science advice to the governmental STI bodies and executive structures within BRICS. The Meeting projects to establish, strengthen and sustain productive joint activities within BRICS with a view to augment capacity development in STI. The role of Academies within BRICS will be determined by a Strategic Plan which is now under elaboration.






# FORESIGHT AND STI POLICY

## Perspectives of Science and Technology in BRICS Countries

The annual BRICS Special Seminar is aimed towards the discussion of vectors of scientific and technological development and priorities of BRICS cooperation; establishing partnerships between scientific and educational organizations of the BRICS countries.

**The key tasks are:**

(1) formation of a strategic system for cooperation in the field of STI between the BRICS countries;
(2) search for answers to common global and regional socio-economic challenges in the BRICS countries using shared experience and complementary opportunities in STI;
(3) joint acquisition of new knowledge and creation of innovative products and services using appropriate financing and investment mechanisms; and
(4) promoting partnerships of BRICS members with other strategic partners of the developing world in the field of STI.



# Projects

# JOINT PROJECT LEAKAGE DETECTION AND SOIL-PIPE INTERACTIONS IN WATER DISTRIBUTION SYSTEMS

Zhejiang University, China
Principal Investigator: Prof. Tuqiao Zhangt

University of Cape Town,South Africa
Principal Investigator: Prof. Jakobus Ernst Van Zyl

Federal University of Ceará, Brazil
Principal Investigator: Prof. Iran Eduardo Lima Neto

**Key pillars of the project**

(1) Experimental and Computational Fluid Dynamics (CFD): Study to measure the pressures, velocities and energy in idealized and real soil beds under different conditions; to measure the erosion of soil surrounding the pipe due to soil-leak interaction under different conditions; to investigate the movement of leak flows outside pipes and the factors that will facilitate leaks appearing above the soil surface.

(China, South Africa, and Brazil)

(2) Laboratory and Computational Fluid Dynamics (CFD): Study to investigate the movement of leak flows outside pipes and the factors that will promote leak detection (China and Brazil). Field studies supported by the Ceará State Water Company (CAGECE, Brazil) as well as numerical modeling of water distribution systems including leak detection and water quality analysis are also planned.

(Brazil)

(3) The mechanism of contamination intrusion under transient flow event, optimal sensor placement in water distribution systems for leakage detection, the diagnosis and pre-warning technology based on pipe rupture simulation and online monitoring.

(China and South Africa)

Prof. Tuqiao Zhang, Prof. Jakobus Ernst Van Zyl and Prof. Iran Eduardo Lima Neto, national project leaders who collaborated before the BRICS project, have common research interests. And yet, the idea of uniting the top three came to them for the first time.

The project started in September 2017 and was designed for three years. Since then, they have had two exchange visits to:

- University of Cape Town, South Africa in 2018,
- Federal University of Ceará, Brazil in 2019.

They also had a plan for a third exchange visit to China, but this was delayed due to the COVID-19 epidemic. The exchange visits are really good for forwarding the Project, as confirmed by theproject leaders: Good research ideas can be generated during the discussion.

The project created a number of related initiatives that the project leaders plan to apply in the future.

# FUNDAMENTALS OF BOTTOM-UP MECHANICAL NANO-ASSEMBLY OF INDIVIDUAL NANO-OBJECTS AND NANO-DEVICES FOR THE STUDY OF QUANTUM AND NON-LOCAL PHENOMENA, NANOELECTRONICS AND NANO-BIO-MEDICAL DIAGNOSTICS

## NATIONAL TEAMS:

Prof. Viktor Koledov
Kotelnikov Institute of Radio Engineering and Electronics

Prof. Somnath Bhattacharyya
University of the Witwatersrand, Johannesburg

Prof. Monica Alonso Cotta
State University of Campinas

Prof. Zhongming Zeng
Chinese Academy of Sciences (SINANO)

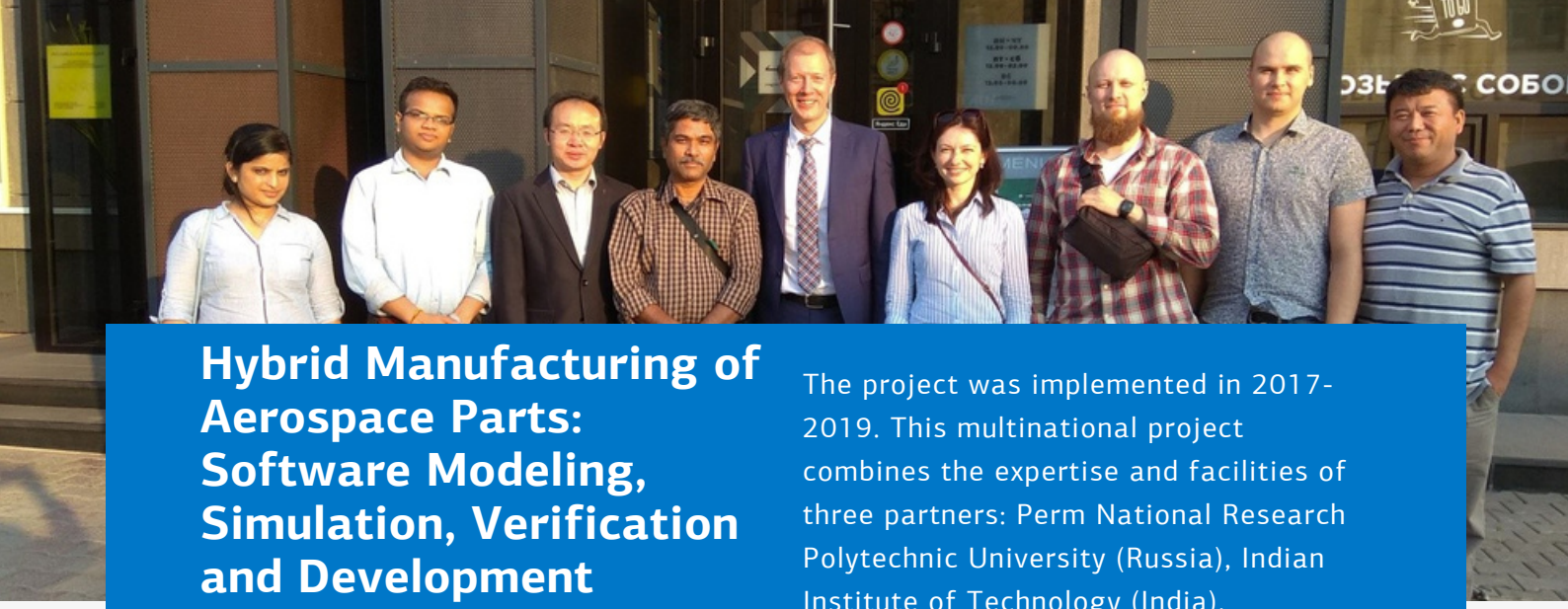
Assistant Professor Digbijoy N. Nath
Indian Institute of Science

## PROJECT DESCRIPTION

The main objectives of the project is to develop for the first time an original “bottom-up” nano-assembly technology and use this technology to create the prototypes of nano-electronic components. The consortium is united by one main idea: the mechanical “bottom-up” nano-assembly and integration can provide a breakthrough, not only in computer and telecommunication technologies and in fundamental research, but also in such areas as alternative energy, biomedical sensors, MEMS, etc. The results of the experiments which were carried out, show that the bottom-up nano-assembly can, in principle, overcome the current barrier in the field of nano-integration of various nano-objects and nano-devices with each other and with standard integrated circuits.

This project sums up the many years of personal acquaintances and creative collaboration with representatives of the Indian (Indian Institute of Science, Bangalore) and South African (University of Watersrand, Johannesburg) groups. Chinese and Brazilian partners enthusiastically responded to requests for participation in a future project by email. Deserved interest is aroused by their publications on the project topic in scientific journals.

Currently, as a result of the project, six papers have been published in collaboration with members of national groups, and 24 articles have been published by the Chinese group with reference to the national part of the project.



# Hybrid Manufacturing of Aerospace Parts: Software Modeling, Simulation, Verification and Development

The project was implemented in 2017-2019. This multinational project combines the expertise and facilities of three partners: Perm National Research Polytechnic University (Russia), Indian Institute of Technology (India), Huazhong University of Science and Technology (China)

The aim of the project was to develop a prototype software designed for numerical modeling of additive formation of large-sized products in the aerospace industry, to determine the parameters of manufacturing modes that reduce residual stresses and deformations in a product for a given set of control parameters, and to expand the functionality of the software and hardware complex of hybrid layer-by-layer manufacturing Multi-Axis Hybrid Layered Manufacturing (MSMA-HLM). Within the project, PNRPU developed the scientific and manufacturing-based foundations of the computer modeling methodology of additive technologies, a computational and experimental method for determining the parameters of manufacturing modes of additive formations of large-sized products in the aerospace industry. PNRPU also helped to select and substantite the values of parameters regarding manufacturing models with the use of wire additive technologies; determine the optimal thermal cycles in the additive formation of products; develop the prototype of a computer expert system for predicting the results of additive formation of large-sized parts of the aerospace industry; and create the database of macro- and microstructures of structural metallic materials obtained by various methods of wire-based additive technologies.

The IITB calibrated and defined the range of functionality of the MSMA-HLM system. Component pilot tests of the MSMA-HLM system with the integrated software created by the consortium members were carried out. Based on the results of the multidimensional modeling, rational values of manufacturing parameters were formed, which were used in hybrid production.

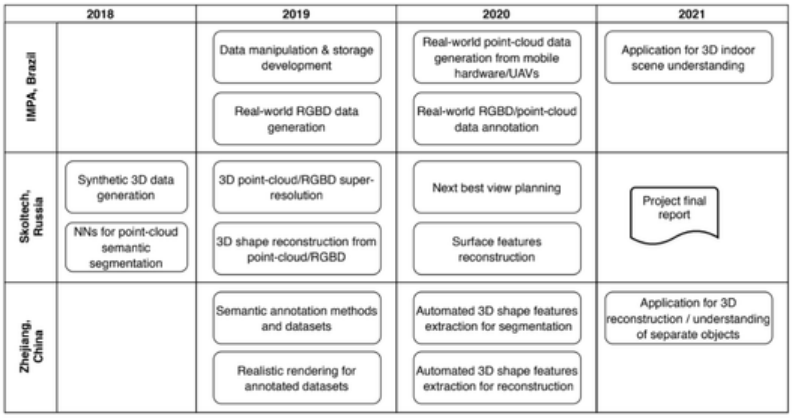
At HUST, a numerical simulation of the process of wire-based laser cladding with a given range of control parameters with an integrated prototype of high-performance software was performed. A prototype of high-performance software was tested for the numerical simulation of the fusion of a wire material with a laser beam at a given range of control parameters. The developed software can be effectively used to simulate the production of large parts due to its high performance, which is achieved through the implementation of a parallel computing model with shared memory.

# Machine Learning Technologies for 3D Data Processing inComputer Vision and Remote Sensing Applications (3DeepCV)

**Associate Professor, Head of ADASE group**
**Evgeny Burnaev (Russia)**
Project role: development of algorithms for 3D data processing

**Full Professor, Head of VISGRAF Lab**
**Luiz Velho (Brazil)**
Project role: generation and annotation of 3D data, development of 3D storage and mobile platform

**Senior Researcher, Zhejiang State Key Lab of CAD&CG PI**
**Youyi Zheng (China)**
Project role: development of algorithms for recovery of 3D shape descriptions




The success of 3D methods has largely been hampered by the lack of labeled datasets suitable for machine learning as well as by the limited ability of existing neural network architectures capable of efficiently processing 3D data in different formats (point clouds, meshes, RGB-D images). Thus, 3D/4D and geometry-aware models are required.

In fact, the field of the learnable methods for geometric data processing is an emerging and interdisciplinary. It is an intersection of computer vision, machine/deep learning and 3D computer graphics. Much of 3D/4D data processing has been optimization-based (e.g. optimal transport, mixed integer optimization for meshing). But learned ability should push data-based domain knowledge to the deep learning model and help to automate and improve the main steps of the pipeline for the geometric (3D/4D) data processing.

The goal of this project is to address both aspects of the problem:

1) methodological developments of general deep learning architectures adapted to semantic modeling of 3D input data (RGB-D images, 3D point clouds etc.) and reconstruction of 3D shapes, as well as development of approaches to training such models on synthetic and human-made labeled data; and

2) their application to the segmentation and 3D shapes reconstruction based on 3D data in different modalities. By “general” deep learning architectures, we mean those not tailored to one specific task (such as face reconstruction, or human body reconstruction), but to a sufficiently broad type of reconstruction problems (e.g., indoor environments, mechanisms, buildings, cityscapes).

# DEVELOPMENT OF SOFTWARE FOR HYBRID PROCESSING, STORAGE AND VISUALIZATION OF LASER SCANNING AND PHOTOGRAPHY DATA BASED ON REAL-TIME DECRYPTION AND VECTORIZATION ALGORITHMS

## PROJECT DESCRIPTION

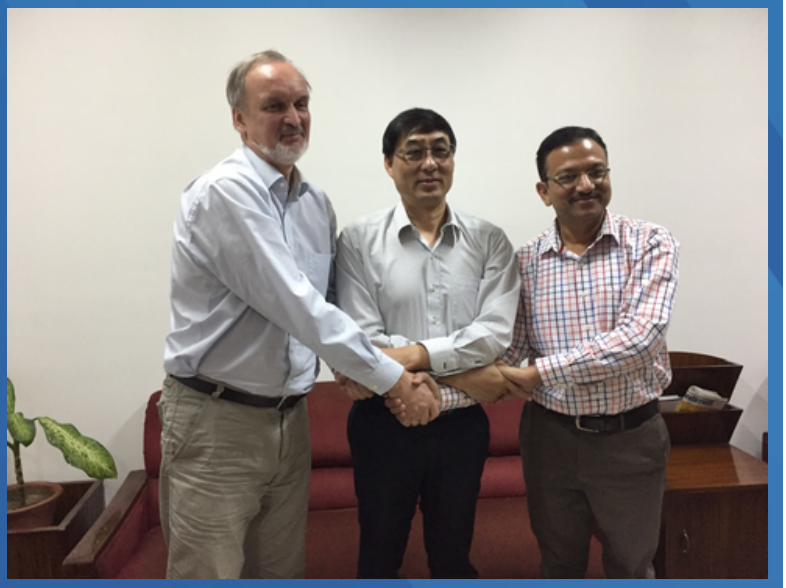
The development of a unified hybrid technology for the processing, storage and visualization of laser scanning and photography data, based on decoding and vectorization algorithms. The technology is used for processing laser scanning data during the civil-engineering survey for the construction process, engineering survey for roads and railways, creating three-dimensional models of the terrain and topography, urban infrastructure, engineering surveying and modeling of a buildings, and industrial sites. Russia will lead the research team to develop new algorithms of cloud of points processing (big data processing) received from laser scanners. Creation of the software for the processing, visualization and vectorization of laser scanning data, as well as the presentation of data through the Internet, to provide:

- improved efficiency and accuracy of laser-scanning data processing (decoding and vectorization not less than 99.5%);
- the customer of laser scanning processes (within the engineering survey) the functionality of the post-processing of results of the scan on the basis of the primary (raw) information about the object( which is the most valuable information).

India will develop new algorithms of cloud of points processing. They will also manage the integration and creation of the software for the processing, visualization and vectorization of laser scanning data, as well as the presentation of data through the Internet.

China will lead the research team to the research and development of three-dimensional laser scanning for the structural health monitoring of the urban infrastructure, and 3D Laser Point Cloud processing, storage and visualization of laser scanning and photography data, based on decoding and vectorization algorithms.

As a result, three collaborative publications are available. Two of them in Scopus Q1.



## NATIONAL TEAMS:

Prof. Vladimir Badenko,
Peter the Great St. Petersburg Polytechnic University

Prof Liu Min, Key
Laboratory of Geographic Information Science of the
Ministry of Education East China Normal University

Prof Rahul Dev Garg,
Indian Institute of Technology Roorkee

## COLLABORATION

Prof. Rahul Dev Garg invited Prof. Vladimir Badenko to participate in the project. Thelatter invited Prof Liu Min, Key. Each year exchange visits were held. There were 2 visits to Russia, 1 visit to India and 3 visits to China.

All visits were very fruitful. A great deal of new contacts was established during visits. Project progress was demonstrated, some revisions from partners were discussed and then realized.

## PROSPECTS FOR THE FUTURE

During the project implementation, the parties agreed to establish a joint international laboratory called "International Smart City LAB". The signing of the agreement on the creation of the laboratory was planned for March-April 2020, but the COVID pandemic disrupted plans. We hope that we will be able to complete the creation of the laboratory by the end of 2020.

The further direction of development of the created algorithms and technologies is clear. Further work is planned in the direction of creating cloud services that implement the developed algorithms. It is planned to create a new international laboratory on the subject of the project. It would be great if the creation of such international laboratories based on the results of projects supported by the BRICS initiative also found financial support from the BRICS committee.

# PHYSICAL BASIS OF DOMAIN ENGINEERING IN PIEZOELECTRIC SINGLE CRYSTALS OF PMN-PT FAMILY AND LEAD-FREE PIEZOCERAMICS

The project is aimed at solving the fundamental scientific problem of the physics of non-equilibrium states related to the description and explanation of the micro- and nanodomain structures under spatially inhomogeneous conditions. The problem was solved by thorough experimental and theoretical investigations of the domain structure evolution in the crystals of relaxor ferroelectrics in the PMN-PT family and lead-free piezoelectric ceramics. This knowledge helps to create the tailored domain patterns with the final goal of improving the piezoelectric characteristics and creating the periodical domain structure for the frequency conversion of the laser light.

Professor Vladimir Shurt

Professor Xiaoyong Wei

Professor Saikh Safiul Islam

## Key pillars of the project

Development and validation of the methods of the domain imaging by optical microscopy, piezoelectric force microscopy, scanning electron microscopy, and confocal Raman microscopy. Detailed experimental investigation and computer modeling of the domain structure evolution in PMN-PT crystals. Creation of the single-domain state. Development of the periodical poling using stripe electrodes, electron and ion beam scanning in view of non-linear optical and piezoelectric applications. Study of the domain structure and its evolution in individual grains of ceramics for various compositions, grain size and orientations.

(Russia)

Improvement of the growth method of rhombohedral and tetragonal PMN-PT single crystals and sintering of BMT-BT and BCZT lead-free piezoceramics. Distribution of the prepared high-quality samples between the partners. Measurement of the macroscopic dielectric, ferroelectric, piezoelectric, optical and nonlinear optical properties, and structural analysis. Production of the prototypes of optoelectric and piezoelectric devices.

(China)

Investigation of the structural and optical properties of PMN-PT single crystals using X-ray diffraction, scanning electron microscopy and dispersive X-ray spectroscopy. Measurement of the electrical properties of single crystals and ceramics in wide temperature range in order to understand the mechanism of electrical conductivity as the key factor of the bulk screening mechanism.

(India)

The effective collaborative research allowed to grow the uniform big size crystals of PMN-PT family and lead-free ceramics and to obtain the deep study of the domain structure evolution in electric field by in situ optical imaging and the static domain patterns at the surface and in the bulk by complementary microscopic methods. The improved new methods of domain engineering in PMN-PT single crystals by field application and scanning by electron and ion beams were developed. The obtained knowledge allowed to improve the methods of domain and domain wall engineering which will be applied for the improvement of the piezoelectric and nonlinear optical devices produced by domain engineering methods in BRICS countries.

Numerous exchange visits of the project partners have been realized within the project. There were short visits of professors with lectures at the seminars and discussions of the joint research and long-term visits of PhD graduates and PhD students for joint investigations. Four very useful BRICS meetings have been organized by all members of consortia.

It is important to point out that the teams have a history of research contacts and collaboration. In May 2016, a seven-persons delegation from Xian Jiaotong University visited Ural Federal University. This visit allowed for the development of joint research in creating new materials with record properties and to sign an agreement. Moreover, in November 2016 Professor Vladimir Shur was invited to India for the inauguration of the Center of nanoscience and nanotechnology of Jamia Millia Islamia in New Delhi, together with famous professor Sumio Iijima of Meijo University in Japan who discovered carbon nanotubes.

# GROUND STATE MAGNETIC STRUCTURE, SPIN DYNAMICS, AND HYPERFINE INTERACTIONS IN FRUSTRATED 3D-METAL BASED HELIMAGNETS: NUCLEAR RESONANCE SPECTROSCOPY STUDY

SUCCESFUL PROJECT OF THE BRICS FRAMEWORK PROGRAMME CALL 2016

## PROJECT SUMMARY

The Project is focused on the revelation of fundamental properties arising from the topology of the spin structure caused by magnetic frustration, as well as the exploration of spin dynamics and hyperfine interactions in the ground state of 3d-metal based helimagnets of various dimensionalities. This objective includes the study of spatial spin configuration of 3d magnetic ions as well as reconstruction of the local hyperfine magnetic field patterns both on magnetic and nonmagnetic ions in the ground state of several helimagnetic materials by means of nuclear resonance spectroscopy including nuclear magnetic resonance (NMR) and zero-field NMR, nuclear quadrupole resonance (NQR), and nuclear gamma-resonance (Mössbauer) spectroscopy.
Magnetically frustrated materials have attracted much scientific attention in recent years due to the rich variety of exotic ground states exhibited by them, which still require theoretical understanding. The most interesting are helical spin systems and quantum spin liquids. In spite of intensive theoretical and experimental study, the details of ground state spatial spin structure, spin dynamics in both paramagnetic and magnetically ordered state as well as the origin, range, and anisotropy of hyperfine interactions in these systems are still unclear. Such information on the microscopic scale is of key importance for our underlying knowledge of basic physics given exotic magnetism.
The Project research tasks are distributed among national scientific teams.

## PRELIMINARY RESULTS

1) 31P NMR experiments of helimagnet FeP both on powder and single crystalline samples with the main goal of examining the transformation of the FeP magnetic helical structure were performed. Zero field NMR spectrum for polycrystalline sample revealed an incommensurate spiral ordering of Fe magnetic moments. The observed transformation of 31P NMR spectrum with increasing magnetic field provides a strong evidence of the spin-reorientation transition in FeP in external fields of 4-5 T confirmed also by specific heat measurements. The shape of the single-crystalline 31P NMR spectrum exhibits a pronounced four-peak structure characteristic of incommensurate helimagnetic ground state with two pairs of inequivalent phosphorus positions. Theoretical estimations of the transferred hyperfine coupling provided an excellent quantitative description of the observed angular dependencies for the peak-to-Larmor field separations.
2) To establish the boundary of the space modulated spin structure (SMSS) existence in the multiferroic Bi1-xLaxFeO3 system, a series of zero-field 57Fe NMR experiments was performed. It was found that substitution of 25% Bi by La in BiFeO3 leads to destruction of SMSS.
3) Together with the Indian team, magnetic properties of Ag3LiRu2O6 and Ag3LiMn2O6 compounds with honeycomb-type crystal structure were studied. Magnetic susceptibility x(T) and neutron powder diffraction indicate the absence of a magnetic transition in Ag3LiRu2O6 down to 1.6 K.

## NATIONAL TEAMS:

Moscow State University, Russia
Principal Investigator: Prof. Andrei A. Gippius

Indian Institute of Technology, India
Principal Investigator: Prof. Avinash V. Mahajan

University of Johannesburg, South Africa
Principal Investigator: Prof. Andre M. Strydom

## PROJECT LEADERS

Prof. Gippius and Prof. Mahajan had a successful joint RFBR-DST project in 2011-2012. They performed intensive joint NMR experiments. The results of these experiments were published in the joint paper. Earlier, Prof. Gippius collaborated with Prof. Strydomearlier earlier in the field of NMR study of strongly correlated electronic systems and they also have a joint paper. Based on the positive experience, all three created a consortia to continue the joint research on NMR.
During the Project run, each national team obtained outstanding scientific results, both joint and partial, which were published in high-ranking international and national scientific journals. These results are of fundamental importance and extend the scope of our understanding of unconventional magnetism in general and helimagnets in particular.
There is complementarity in the experimental methods, facilities and infrastructure between national research teams involved in the project. Therefore, the three scientific groups together bring in a unique blend of expertise ranging from sample preparation to bulk and local probe measurements coupled with theoretical analysis in a variety of exotic magnetic systems.

A power law ~T4 decrease in the spin-lattice relaxation rate 1/T1 below 2 K was observed indicating that the spin system at T→0 remains dynamic, and the excitation spectrum remains gapless, which is typical for systems with spinspectrum to remain gapless, which is typical for systems with spin liquid properties too. In contrast, NMR experiments and thermodynamic measurements indicate the formation of a long-range AFM order in isostructural compound Ag3LiMn2O6 at 47K.


# BRICS – BEST

## Bioenergy from eco-sustainable technology

Global lignocellulosic biomass production exceeds 220 billion tons annually, while BRICS countries being highest producers of sugarcane, rice and maize, generate significant amount of lignocellulosic biomass. Unfortunately, most of the biomass remains unutilized or is burnt which results in wastage of potential high-energy sources and drastic deterioration of air quality and generation of carcinogenic chemicals. It is, therefore, of major global interest to use biomass as a renewable energy source and produce commercially-important co-products. Intensification of biomass to bioenergy conversion is preferred over non-renewable and polluting fossil fuels to meet the increasing global energy demand. Bioenergy represents around 10% of the total world energy consumption today, and the growth rate of biofuel production has been around 15% per year in the last decade. The use of lignocellulosic residues is being actively researched, but the economic conversion of these materials into viable products is a major challenge that demands an interdisciplinary and integrated approach.

The BRICS technology platform comprises researchers from Brazil, Russia, India, China, and South Africa. This collaborative effort will focus on integral conversions of biomass into biofuels in a synergistic approach, exchanging experiences and knowledge, and developing local capacity for enhancement of bioenergy production chains through biorefinery approaches. Major lignocellulosic biomass such as oil palm solid residues from Brazil, rice straw from China and India, sugarcane bagasse from South Africa and wood residues from Russia are being investigated for eco-sustainable production of bioethanol and co-products in a zero-waste approach.
A major part of the final goal of the project was to ensure successful collaboration within the group after the funding period and regular movement of staff and students occurred in 2019 and to a limited extent in 2020. Two joint meetings were held at DUT in March 2019 and India in November 2019.

On the top photo from left to right: Dr Ivan Zorov, Moscow State University; Dr Alexandra Rozhkova, Russian Academy of Science; Prof Suren Singh, DUT; Prof Kugen Permaul, Project Leader, DUT; Prof Júlio de Carvalho, University of Paraná; Prof Carlos Soccol, Research Leader, University of Paraná; Mr Fei Mingxing, Chinese Consul General; Prof Zhengxiang Wang, Research Leader, Tianjin University of Technology; Prof Theo Andrew, DUT.

# DEVELOPMENT OF MEMBRANE-BASED METHODS TO IMPROVE THE RECOVERY OF PURE WATER AND VALUABLE PRODUCTS FROM THE WASTE

The continuous growth of human population and the world economy will further challenge the fresh water supply for drinking and agriculture. The inevitable consequence is more municipal wastes and groundwater contaminated with pesticides and fertilizers. The other major source of water contamination relates to the increased consumption of different types of goods including electronic devices. The production of these goods triggers more intensive discovery of carbon- and minerals-based natural resources from underground depositions. This will continuously shift the balance of chemical elements since the fate of all these carbon- and mineral-based compounds will be in the polluted streams generated during each stage of the whole life cycle of the products. The reuse of these contaminated streams and recovery of valuable chemicals are of key importance to the sustainability of humanity and the world economy.

The goal of this project is to develop membrane-based processes that can significantly reduce the energy consumption and the cost, and can be operated independently for:

- effective operation in remote areas to produce clean water and
- recovery of both organic and inorganic components together, with clean water from the polluted water.

Extraction of resources from waste streams is changing the paradigm of waste management. Recovering the maximum amount of these resources remains a great challenge to scientists and engineers. Teams are responsible for:

(1) removal of electrically charged pollutants followed by their reduction or oxidation into neutral species by using the electrodialysis method

(2)polymeric membranes with advanced surface properties and solvent/acid resistance for recovery and concentration of precious metals

(3) development of ultrafiltration/nanofiltration high performance ceramic membranes with improved chemical and fouling resistance

(4) valuable metals recovery utilizing membrane distillation with porous condenser

(5) selective removal and recovery of nutrients (e.g. PO43-, NO3-) by ion exchange membranes

# The role of region-specific SNPs in virulence genes in Mycobacterium tuberculosis drug resistance. Digest

Dr. Dmitry Maslov (key participant, Russia), Prof. Martie Van der Walt (PI, South Africa) and Prof. Valery Danilenko (PI, Russia); Dr. Ligyun Shao (PI, China).

We had a long journey prior to the preparation of our BRICS application. Back in 2010 the TBResist consortium – which brought together researchers from 20 countries and aimed to analyze Mycobacterium tuberculosis whole-genomic sequences to discover novel mechanisms of drug resistance – was established. Russia, China and South Africa are countries highly burdened with tuberculosis, accounting for almost 13% of global tuberculosis cases. Thus it was a logical step for Prof. Valery Danilenko from Vavilov Institute of General Genetics RAS, Prof. Martie Van der Walt from the TB Platform of the South African Medical Research Council and Dr. Lingyun Shao from Fudan University to join their efforts. Currently, it is known that the clinical manifestations and epidemiology of tuberculosis largely depend on the balance between the host's immune system and the pathogen's virulence systems. The causative agent of tuberculosis in the human body is often in a latent form, and the key factor affecting the transition to active TB is a decrease in immunity, which can be caused by various reasons, including the presence of concomitant diseases that lead to a decrease in immunity. Also the M. tuberculosis genome includes more than three hundred virulence genes, whose products are involved in various stages of the infectious process and allow colonization of the host's mucosa, to infiltrate cells, avoid the immune system response, survive adverse conditions, etc. Different lines of M. tuberculosis are characterized by variations in pathogenicity genes, which can lead to changes in protein properties, and, as a result, to changes in the virulence profile. This multifactorial evolution of MTB lead to a spread of "successful" clones in different geographic locations. The emergence of new sublineages within the "successful" clones, which are associated with drug-resistant phenotypes and harbor a number of specific mutations in virulence-associated genes, has been observed of late. Enhanced virulence may be linked to drug resistance.

**Our project aim is to identify SNPs in virulence genes, associated with drug-resistant phenotype of M. tuberculosis belonging to geographical-specific lineages that emerged in the era of antibiotics. Each partner analyzed a collection of clinical MTB isolates derived from their respective country to fulfill the aim.**

To support the international collaboration, several exchange visits were made. The project implementation led to the detection of mutations in M. tuberculosis virulence genes specific to Russia. An important result of the collaboration was the training of researchers from South Africa in the VIGG RAS laboratory of bacterial genetics, aimed at mastering the methods of molecular genetic manipulation of mycobacteria. The work that is currently carried after the project's closure is focused on a general phylogenetic analysis of all sequenced genomes from Russia, China and South Africa in order to identify common SNPs that potentially characterize the common path of evolution of epidemiologically dangerous strains. We believe that this work will lead to a high-impact joint publication.

The implementation of this BRICS project has also stimulated the creation of the Russian tuberculosis consortium, which includes circa 20 Institutes and organizations in Russia, and has also given a start to new areas of collaboration in the field of tuberculosis research with other groups in China and South Africa.

# BRICS STI Publication Dynamics

# BRICS STI DYNAMICS

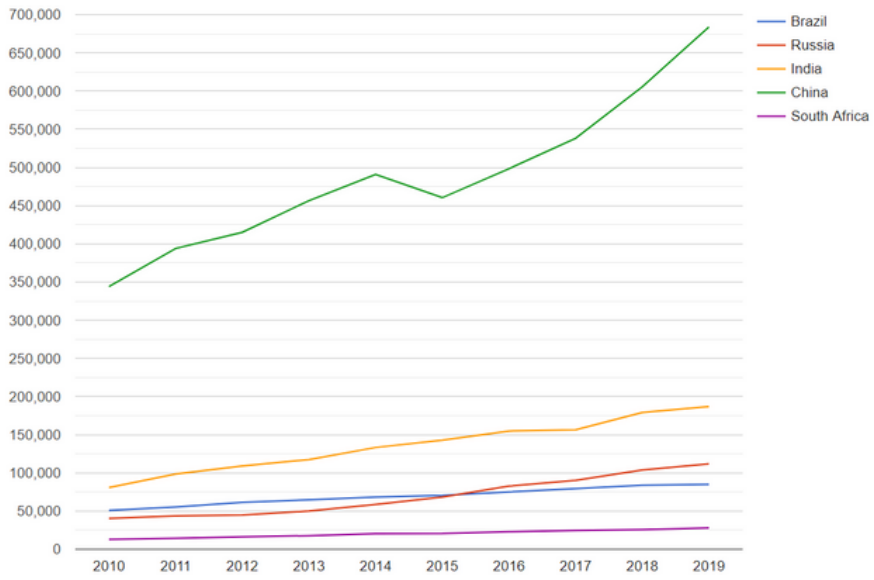
**1.2 M**

total number of BRICS publications indexed in Scopus in 2019

**26%**

of world Scopus publications

**Dynamics of publications in the BRICS countries from 2010 to 2019**




The Scopus® database (Elsevier B.V.)[2] shapes of BRICS science reflects the majority of publications in the fields of mathematics, medicine and multidisciplinary research.

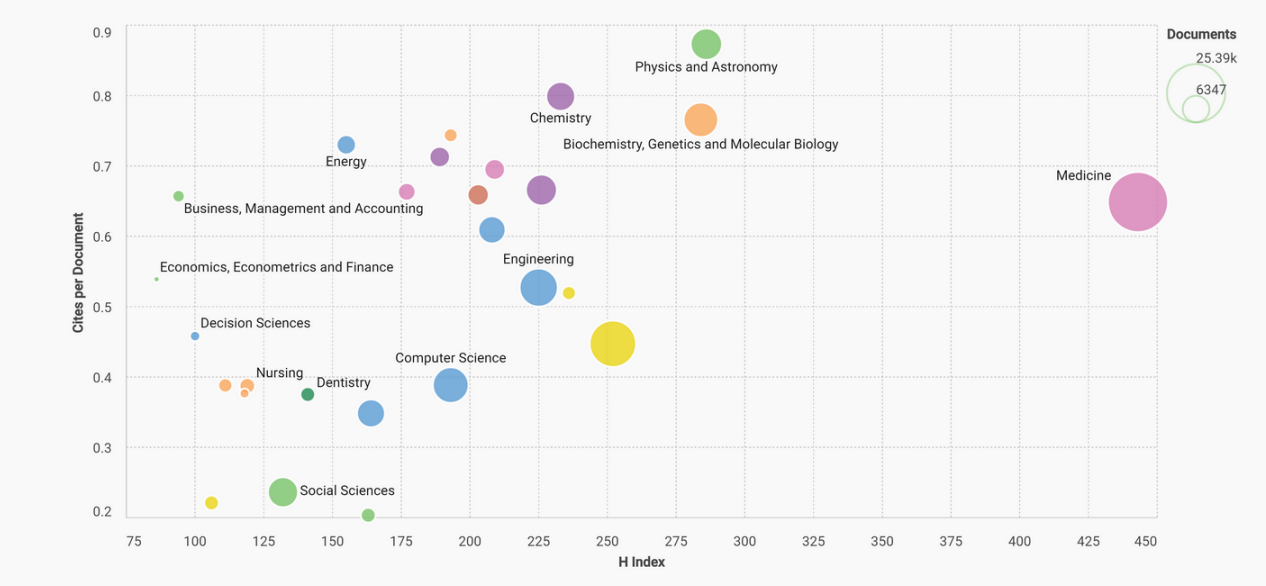

[2] SCImago, (n.d.). SJR — SCImago Journal & Country Rank [Portal]. Retrieved Date you Retrieve, from http://www.scimagojr.com

# BRAZIL

Brazil`s leading scientific field is medicine with 25388 (about 30% of its total 84887 papers) ranked by Scopus in 2019. The general publication output of BRICS in 2019 was 7,53% – and there is a smooth decrease – while in medicine it takes 11.48 percent. Other leading areas of research are Agricultural and Biological sciences, Engineering, Biochemistry, Genetics and Molecular Biology.

As for Brazil`s priority in BRICS – climate change and natural disaster mitigation – the number of science papers ranked by Scopus has doubled in the last five years..

International collaboration has increased since 2015. Brazil maintains the positive dynamics since 2010. Today, 35% affiliations with Brazilian research papers are made in international co-authorship.

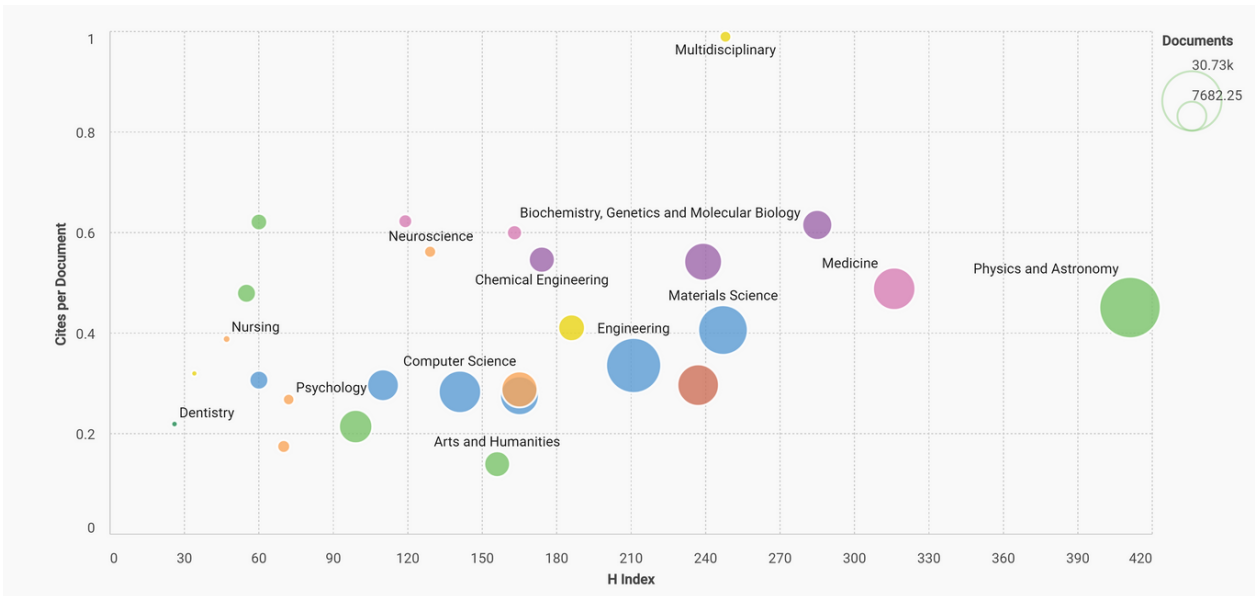



# RUSSIA

Russia is well-known for its multidisciplinary research and explorations in fundamental sciences.. Statistically, its leading areas are Physics and Astronomy, Engineering and Material Sciences. Still, the H-index in Medicine cannot be overlooked. Russia S&T output of BRICS has been stable for the last five years and is about 10%.

The output of Russian research in water resources and pollution treatment has increased by 36,5% since 2015.

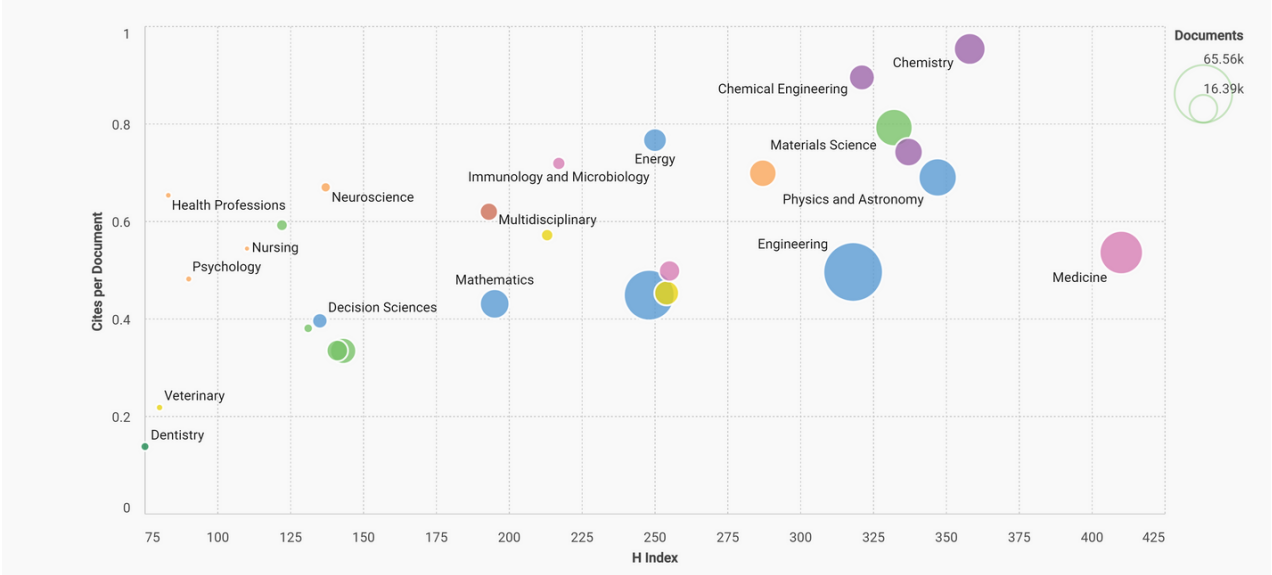
Yet, the percentage of papers prepared in international collaboration has decreased considerably since 2014. This could be the result of national politics focused on increasing quantitative indicators of publications, reflecting on share value.



# INDIA

Scopus ranks India in the world's Top Ten countries. It's global research output is continuously rising; India`s output share of BRICS is about 17%. The average citation per document is close to 10. The most elaborated scientific area for India is Engineering with 65559 publications in 2019, followed by Computer Science. Still, the most cited publications are in the field of Medicine. The third of papers indexed by Scopus are made in international collaboration.

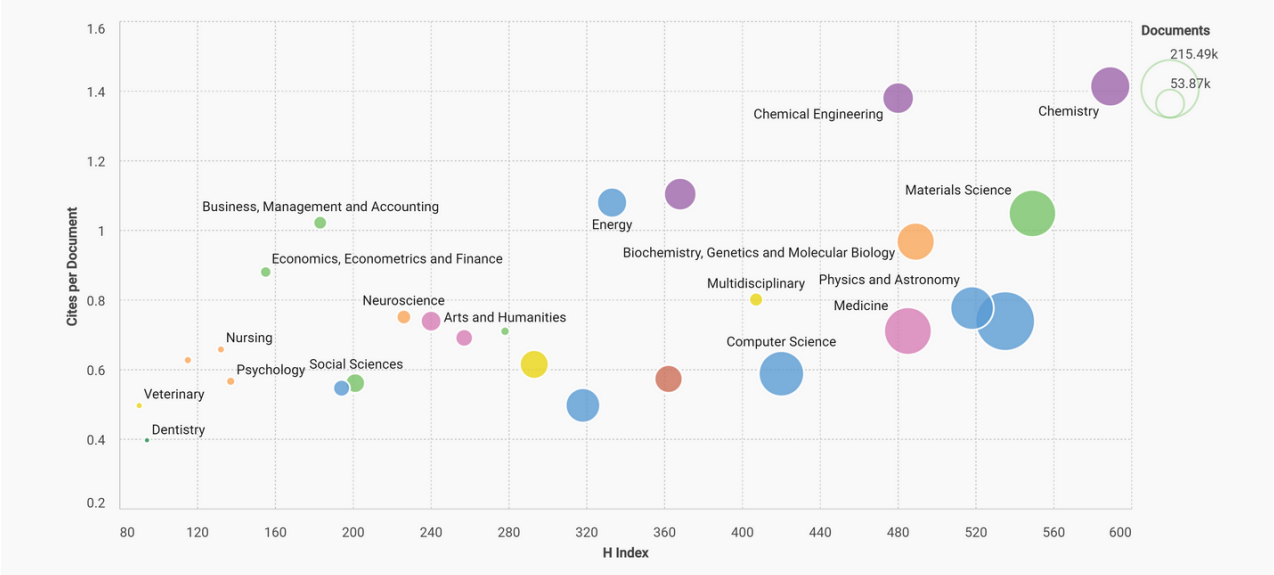
The number of publications in Space and Planetary Science and Geotechnical Engineering which corresponds to the scientific priority of India in BRICS demonstrates a considerable and stable growth with a significant jump in last two years.




# CHINA

China is the world leader in publication activity after the United States. Its share of output in BRICS is more than 60 percent. China is continuously increasing the number of publications made in international collaboration, and as of 2019, the share of such publications is approaching a quarter.

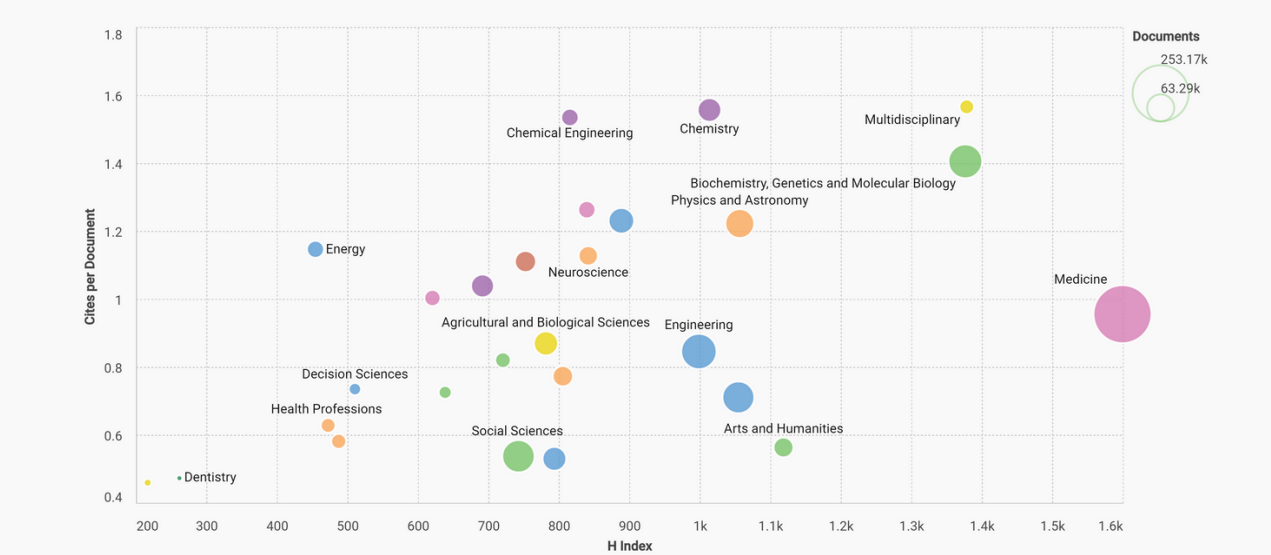
China`s leading research area is Engineering followed by Medicine, Material Science and Computer Science. The number of publications in Energy has more than doubled since 2015. Despite a relatively small number of publications, Chemistry remains the most cited scientific field for China.



# SOUTH AFRICA

Among BRICS countries, South Africa is the absolute leader in citation rate, at 14,59 per document. More than half of affiliations with South African documents are made in international collaboration. As for Brazil, Medicine is the leading scientific area for South Africa.

The elaboration of Astronomy in South Africa – priority area for BRICS – demonstrates a non-negligible progress. The number of publications has risen by 46% since 2015.




## BRICS PUBLICATION SYNERGY

As of 2017, BRICS countries account for 17% of global investment in research and development and 27% of scientific publications indexed in the Web of Science. The share of publications, prepared in the framework of joint projects is 15% of the total publications in South Africa, 10% in Russia and India, 8.5% in Brazil and 3% in China. Most active cooperation is carried out in such areas as physics, astronomy, medicine, mechanical engineering, materials science, chemistry and biochemistry, genetics, molecular biology, agriculture and biological sciences. There is groundwork for expanding scientific interaction in the field of science of decision-making, artificial intelligence, veterinary medicine, economics and humanities.

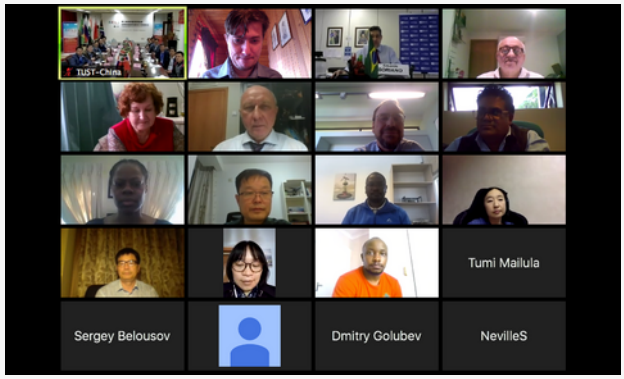
# Facing the challenges of 2020

The COVID-19 pandemic moderated the BRICS projects for the year 2020. Still, BRICS countries faced it bravely and efficiently.

Six expert meetings within the framework of the Russian initiative to organize networking of research organizations, as well as representatives of the business community of the BRICS countries, were held in June and July in a video format. Each thematic session was attended by about 55 representatives of the research and business communities of the BRICS countries. The participants presented overview reports on the current state of affairs in the BRICS countries, exchanged contacts for further interaction, including the submission of applications for participation in the BRICS NTI Framework Programme competition.

- Research, new technologies and tools for diagnosing a new type of COVID-19 coronavirus infection;;
- research and development of vaccines against COVID-19, including the repurposing of available vaccines;
- drug research and development for COVID-19, including the repurposing of affordable drugs was held by Russia ten days after the first videoconference;
- genomic sequencing of SARS-CoV-2 and studies on epidemiology and mathematical modeling of the COVID-19 pandemic;
- research in artificial intelligence, ICT and HPC, aimed at the development of drugs for the treatment of COVID-19, the development of vaccines, therapies, clinical trials, and infrastructure and health systems; and
- epidemiological studies and clinical trials to evaluate the overlap of SARS-CoV-2 and comorbidities, especially tuberculosis.





# CONCLUSION

By analyzing the role of BRICS in global development trends, we can ascertain the great integration potential and combined influence on the world political landscape and leadership. BRICS certainly is a potential powerhouse of the modern world. The last five years of fruitful and prosperous cooperation between BRICS in the field of STI is an undeniable example of their strong status as emerging economies.

In accordance with the New BRICS STI Architecture, future STI development will be determined by four main pillars, combining joint research and a collective infrastructure for innovation and sustainable development.

Facing the COVID-19 pandemic of 2020, the BRICS STI framework demonstrates clear coordination of actions to realize mutual interests, which testifies to a strong commitment to common goals and an effective governance system resilient to unexpected challenges.

Today, all eyes are upon the scientific community, which is being called on to combine efforts through international scientific and technical cooperation. In this regard, it is gratifying to note the availability of BRICS working tools, financial mechanisms, dialogue platforms and partnerships.

**Photos are provided by the Ministry of Science, Technology and Innovation of Brazil, Ministry of Science and Technology of China, Ministry of Science and Higher Education of Russia, BRICS WGs and project teams, Host Photo Agency, JINR, TSAGI, Neila Rocha and Charles Takali.**

## FOR NOTES AND IDEAS